MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

VOLUME 131(3) JULY–SEPTEMBER 2016

Stanjehughesia jiangxiensis sp. nov.

JIAN MA— FIG. 2, p. 586

ISSN (PRINT) 0093-4666 http://dx.doi.org/10.5248/131-3 ISSN (ONLINE) 2154-8889

MYXNAE 131(3): I–X + 491–734 (2016)

Editorial Advisory Board

Peter Buchanan (2011–2017), Chair
Auckland, New Zealand

Sabine Huhndorf (2011–2016), Past Chair
Chicago, Illinois, U.S.A.

Brandon Matheny (2013-2018)
Knoxville, Tennessee, U.S.A.

Karen Hansen (2014-2019)
Stockholm, Sweden

ISSN 0093-4666 (print)

ISSN 2154-8889 (online)

MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

April–June 2016

Volume 131 (3)

http://dx.doi.org/10.5248/131-3

Editor-in-Chief

Lorelei L. Norvell

editor@mycotaxon.com
Pacific Northwest Mycology Service
6720 NW Skyline Boulevard
Portland, Oregon 97229-1309 USA

Nomenclature Editor

Shaun R. Pennycook

PennycookS@LandcareResearch.co.nz
Manaaki Whenua Landcare Research
Auckland, New Zealand

Mycotaxon, Ltd. © 2016

www.mycotaxon.com &
www.ingentaconnect.com/content/mtax/mt
p.o. box 264, Ithaca, NY 14581-0264, USA

MYCOTAXON

volume one hundred thirty-one (3) — table of contents

Cover section

Reviewers vii
Submission procedures viii
From the Editor ix

Research articles

Periconia notabilis sp., nov. and a new record and notes on the genus in Thailand — Charuwan Chuaseeharonnachai, Sayanh Somrithipol & Nattawut Boonyuen 491

New host records of rust fungi (*Pucciniales*) from Pakistan — B. Ali, Y. Sohail & A.S. Mumtaz 503

New records of myxomycetes from México — Marcos Lizárraga, Gabriel Moreno & Martín Esqueda 511

Marthamyces coronadoae sp. nov. in a *Fagus grandifolia* var. *mexicana* forest from Hidalgo State, México — Tania Raymundo, Ricardo Valenzuela & Martín Esqueda 521

Lithothelium bermudense sp. nov., a new saxicolous lichen from Bermuda — Franz Berger, Scott LaGreca & André Aptroot 527

Harmoniella campanaensis sp. nov. from central Chile — Hugo Madrid, Daniela Torres & Víctor Silva 535

Rosellinia hainanensis sp. nov. and three *Rosellinia* species new to China — Wei Li & Lin Guo 541

Phaeomonilia nanningensis sp. nov. and a new *Craspedodidymum* record from southern China — Chun-Ling Yang, Jin-Ye Wang, Ji-Wen Xia, Ying-Rui Ma, Jian-Mei Gao & Xiu-Guo Zhang 547

Pseudoacrodictys from southern China: *P. ambigua* sp. nov. and a new record — Jian-Mei Gao, Jin-Ye Wang, Chun-Ling Yang, Ji-Wen Xia, Ying-Rui Ma & Xiu-Guo Zhang 553

Capsicispora mycophila gen. & sp. nov. from southern China — Jin-Ye Wang, Chun-Ling Yang, Ji-Wen Xia, Ying-Rui Ma, Jian-Mei Gao, Yu-Mei Cai & Xiu-Guo Zhang 559

Diploschistes tianshanensis sp. nov., a corticolous species from Northwestern China — Gulibahaer Ababaikeli, Abdulla Abbas, Shou-Yu Guo, Aniwaer Tumier & Reyimu Mamuti 565

Sporidesmiella lushanensis and *S. jiulianshanensis* spp. nov. and a new record from China Jian Ma 575

Corynesporopsis obclavata and *Stanjehughesia jiangxiensis* spp. nov. from Lushan Mountain, China Jian Ma 583

New records of *Rhizocarpon* from Hengduan Mountains, China Wei-Cheng Wang, Zhao-Jie Ren, Lu-Lu Zhang & Zun-Tian Zhao 589

Ellisembia henanensis sp. nov. and two new hyphomycete records from central China Ji-Wen Xia, Jin-Ye Wang, Chun-Ling Yang, Zhuang Li & Xiu-Guo Zhang 597

Thozetella coronata and *T. ypsiloidea* spp. nov. from the Brazilian Amazon forest Josiane Santana Monteiro, Rafael F. Castañeda-Ruiz & Luís Fernando Pascholati Gusmão 605

Long-hidden in Thaxter's treasure trove: *Laboulbenia camerunensis* sp. nov. parasitic on African *Curculionidae* Tristan W. Wang, Danny Haelewaters & Donald H. Pfister 613

Erysiphe acantholimonis sp. nov. on *Acantholimon hedinii* Jia-Ge Song, Biao Xu, Shan-He Zhang, Zhen-Yu Zhao, Sung-Eun Cho & Hyeon-Dong Shin 621

Tubulicrinis martinicensis sp. nov., a corticioid species from Martinique (French West Indies) Gérald Gruhn, Nils Hallenberg & Régis Courtecuisse 631

Roccella elisabethae with lichenicolous *Arthonia follmanniana* in Turkey Mehmet Gökhan Halici & Arife Merve Kahraman 639

Diaporthe henanensis sp. nov., an endophytic fungus in *Ziziphus jujuba* from China Yi Yang, Yu-Xia Guo, Ya-Kun Zhang, Hai-yan Wu & Meng Zhang 645

Notes on rust fungi in China 1. Autoecious life cycle of *Puccinia tatarinovii* on *Prenanthes* Jing-Xin Ji, Qi Wang, Zhuang Li, Yu Li & Makoto Kakishima 653

Gymnopus ramulicola sp. nov., a pinkish species from southern China Shu-Fang Deng, Tai-Hui Li, Zi-De Jiang & Bin Song 663

Hemithecium hainanense sp. nov. with a checklist and key to *Hemithecium* species from China Ze-Feng Jia, Mei-Fang Li & Xin Zhao 671

First record of *Faurelina* in the Neotropics Roger Fagner Ribeiro Melo, Andrew N. Miller & Leonor Costa Maia 679

Anaverticicladus uncinatus gen. & sp. nov. from decaying leaves from Brazil Phelipe M.O. Costa, Marcela A. Barbosa, Elaine Malosso & Rafael F. Castañeda-Ruiz 687

Morphology and phylogeny of *Cladosporium subuliforme*, causing yellow leaf spot of pepper in Cuba Beatriz Ramos-García, Tomas Shagarodsky, Marcelo Sandoval-Denis, Yarelis Ortiz, Elaine Malosso, Phelipe M.O. Costa, J. Guarro, David W. Minter, Daynet Sosa, Simón Pérez-Martínez & Rafael F. Castañeda-Ruiz 693

Boletus durhamensis sp. nov. from North Carolina Beatriz Ortiz-Santana, Alan E. Bessette & Owen L. McConnell 703

Diorygma fuscum sp. nov. from China Jian Li & Ze-Feng Jia 717

Book reviews and notices Lorelei L. Norvell 723

Mushrooms of the Redwood Coast—a comprehensive guide to the fungi of coastal northern California Noah Siegel & Christian Schwarz

Fungi of Northern Europe—Vol. 5. The genus *Mycena* s.l. Arne Aronsen & Thomas Læssøe

Nomenclatural novelties and typifications proposed in volume 131(3) 733

publication date for volume one hundred thirty-one (2)

Mycotaxon *for* April–June 2016, (i–xii + 263–490)

was issued on August 12, 2016

Reviewers — volume one hundred thirty-one (3)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this quarter.

Vladimir Antonin
Alan W. Archer
José Luiz Bezerra
Meredith Blackwell
Uwe Braun
Jose Francisco Cano-Lira
R.F. Castañeda-Ruiz
Cvetomir M. Denchev
Jorge Raúl Deschamps
Adam Flakus
Genevieve Gates
Josepa Gené
Roy E Halling
Liu-Fu Han
David L Hawksworth
Peter Johnston
Santosh Joshi
Alfredo Justo
Bryce Kendrick
Kerry Knudsen
De-Wei Li
Hua-Jie Liu
José G. Marmolejo
Eric H.C. McKenzie
Armin Mešić
Josiane S. Monteiro
Akira Nakagiri
Lorelei L. Norvell
Shaun R. Pennycook
Sergio Pérez-Ortega
Liliane Petrini
Walter P. Pfliegler
Huzefa A. Raja
Roger Rosentreter
Amy Rossman
Isabel Salcedo
Roger G. Shivas
Steven L. Stephenson
Susumu Takamatsu
Merje Toome-Heller
Larissa Vasilyeva
Martin Westberg
Xiu-Guo Zhang

Four steps to successful Mycotaxon publication in 2016

Prospective Mycotaxon authors should download instructions PDF, review and submission forms, and other helpful templates by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. Below is a summary of our '4-step' publication process.

1—Peer review: Email formatted text and illustration files with a 2014 Mycotaxon Reviewer Comments Form to 2–3 experts for peer review. Authors should (i) ask peer reviewers to return revisions and comment forms to both authors and *Editor-in-Chief* <editor@mycotaxon.com> and (ii) follow reviewer suggestions **before** sending revised files to the *Nomenclature Editor* for nomenclatural review.

2—Nomenclatural review: Email all text-based files (with phylotrees & other text-based art) to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz> for accession and pre-submission review. Place 'Mycotaxon' + first author surname on the subject line; list all peer reviewer names+Email addresses in the message. The Nomenclature Editor will assign accession numbers and return annotated files with a list of needed corrections to the authors and *Editor-in-Chief.*

3—Final submission: Consult experts, revise and thoroughly proof manuscripts, and prepare error-free text and image files ready for immediate publication. Label the Email **and all files** with the accession number before attaching the (i) 2016 Mycotaxon submission form; (ii) text files for main text, tables, and legends; (iii) final art files to the *Editor-in-Chief* <editor@mycotaxon.com>, and (iv—NEW!) nomenclatural identification verification for each new name. The *Editor-in-Chief* usually Emails all coauthors and expert reviewers within two weeks of final submission, but please wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & press preparation: Files not ready for publication will be rejected or returned to authors for further revision; the *Editor-in-Chief* gives tentatvely approved manuscripts a final grammatical and scientific review before converting all files into publishable format. The PDF proof, bibliographic citation, and nomenclatural entries are sent to all coauthors for final inspection prior to publication. Thereafter, the *Editor-in-Chief* corrects only processing or editorial errors prior to publication but will list corrections of author errors in the Errata of a subsequent volume for no charge. Authors are expected to arrange payment of page charges and optional open access fees with the *Business Manager* <subscriptions@mycotaxon.com> at this time.

Mycotaxon ltd— www.mycotaxon.com

The Mycotaxon *Webmaster* <mycotaxon@gmail.com> posts general and subscription information, important announcements, and author forms and templates on the official Mycotaxon site. The server also hosts the regional mycobiota webpage for free download of distributional annotated species lists.

Mycotaxon online— www.ingentaconnect.com/content/mtax/mt

Mycotaxon publishes four quarterly issues per year. Both open access and subscription articles are offered.

Richard P. Korf, mycological giant [1925–2016]—Eight Saturdays ago, on August 20, this journal lost its mentor and co-founder, who passed away after a bout of pneumonia at the age of 91. Although a death occurring in the tenth decade of life should not be unexpected, the news came as a shock to the editorial office and left us feeling decidedly adrift in far too vast mycological sea. Mycotaxon had hoped to publish a memoriam to Dick in this issue, but as two months proved too short a time to assemble the materials to do him justice, we hope to close out 2016 by publishing in our October–December issue reminiscences of our spirited scientist, nomenclaturalist, international forayer, actor, and self-proclaimed curmudgeon.

We invite any and all of you to send in your photographs, anecdotes, and musings to give Dick the rousing send-off he so richly deserves. Please send your reflections—before December 15, if possible—to Mycotaxon in care of my office via editor@mycotaxon.com.

Mycotaxon 130-3 presents 30 papers by 114 authors (representing 19 countries) and revised by 43 expert reviewers.

Within its pages are two new genera (*Anaverticicladus* from Brazil, *Capsicispora* from China) and 25 species new to science representing *Anaverticicladus* & *Thozetella* from Brazil; *Boletus* from U.S.A.; *Capsicispora, Corynesporopsis, Diaporthe, Diorygma, Diploschistes, Ellisembia, Erysiphe, Gymnopus, Hemithecium, Phaeomonilia, Pseudoacrodictys, Rosellinia, Sporidesmiella,* and *Stanjehughesia* from China; *Harmoniella* from Chile; *Laboulbenia* from Cameroon; *Lithothelium* from Bermuda; *Marthamyces* from Mexico; *Periconia* from Thailand; and *Tubulicrinis* from French West Indies.

In addition to range extensions and/or new hosts for previously named taxa in *Faurelina* (Brazil), *Puccinia* (Pakistan), *Rhizocarpon* (China), and *Badhamia, Didymium, Echinostelium, Perichaena,* and *Physarum* (Mexico), we also offer a presentation of the autoecious life cycle of *Puccinia tatarinovii* (here newly lecto-/epitypified), morphological and phylogenetic analyses of the *Cladosporium* causing yellow leaf spot on peppers in Cuba, and new keys to *Erysiphe* on plumbaginaceous hosts, *Faurelina* worldwide, *Hemithecium* in China, *Marthamyces* in America, *Phaeomonilia* worldwide, and *Tubulicrinis* worldwide.

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)

8 October 2016

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 491–502

http://dx.doi.org/10.5248/131.491

Periconia notabilis sp. nov. and a new record and notes on the genus in Thailand

Charuwan Chuaseeharonnachai*, Sayanh Somrithipol & Nattawut Boonyuen

BIOTEC, National Science and Technology Development Agency (NSTDA), 113 Thailand Science Park, Thanon Phahonyothin, Tambon Khlong Nueng, Amphoe Khlong Luang, Pathum Thani 12120, Thailand

* Correspondence to: *charuwan.chu@biotec.or.th*

Abstract—*Periconia notabilis* is described and illustrated as a new species discovered on a dead twig of *Delonix regia* in a terrestrial habitat, Pathum Thani Province, Thailand. It differs from all other *Periconia* species by its pale brown to brown spherical sheath around each conidiophore regeneration point. *Periconia obscurata* is reported from Thailand for the first time, and five other *Periconia* spp. are described and illustrated from Thai collections.

Key words—asexual fungi, microfungi, decaying plants, morphology, fungal taxonomy

Introduction

Periconia (*Pleosporales*, *Dothideomycetes*) is a polyphyletic genus. *Periconia* was introduced by Tode (1791) with *P. lichenoides* as the type species. Its systematics based on molecular phylogeny are unclear (Markovskaja & Kačergius 2014). *Periconia* species are known from various geographical locations and on different hosts, reported as herbaceous endophytes, plant pathogens on leaves and roots, and terrestrial saprobes found in mangrove, marine, and hypersaline ecosystems (Alias & Jones 2000; Cantrell et al. 2007; Earle 1902; Ellis 1971, 1976; El-Sharouny et al. 2009; Kohlmeyer 1977; Markovskaja & Kačergius 2014; Rao & Rao 1964; Whitton et al. 2012).

Periconia is characterized by conidiophores that are macronematous or sometimes micronematous, mononematous, branched or unbranched, sometimes setose, septate, erect, pale to dark brown, smooth or rarely

verruculose at the apical part of conidial head and conidiogenous cells that are monoblastic or polyblastic, ellipsoidal to spherical, discrete, formed on a stipe or branches, sometimes the conidiogenous cells arise from the lower part of the conidiophores. Conidia are blastocatenate, but maturing from basipetal, pale to dark brown, aseptate, spherical, ellipsoidal to oblong, smooth or ornamented (Ellis 1971, Markovskaja & Kačergius 2014).

Currently, the genus *Periconia* includes c. 40 accepted species (Kirk et al. 2008, Seifert et al. 2011).

During our continuing (2010–12) survey of saprophytic hyphomycetes associated with plant debris and saprobic micro-fungi from several collecting sites in Thailand, we found a new species described here as *Periconia notabilis* as well as specimens of six other *Periconia* species: *P. obscurata* (a new record for Thailand), *P. byssoides*, *P. cookei*, *P. echinochloae*, *P. lateralis*, and *P. sacchari*. Our descriptions and illustrations are based on morphological observations from the natural substrate, as attempts at isolation failed for several species.

Materials & methods

Our new species, *P. echinochloae, P. lateralis*, and *P. sacchari* were collected from decaying leaves and twigs in Pathum Thani Province; the three other *Periconia* species were collected in different provinces: *P. byssoides* and *P. obscurata* from Kanchanaburi Province and *P. cookei* from Chiang Rai Province. Samples were taken to the laboratory in polythene bags, rinsed in sterilized distilled water, and incubated in a moist chamber at room temperature (~20°C) for at least 14 days. Unfortunately, attempts to isolate and culture *P. notabilis* using a mono-spore technique failed. Because of limited type material and non-germinated conidia, the taxonomic description of the new species in this paper is based only on morphological characteristics without molecular data. Fungal cultures with successful isolation (*P. cookei*, *P. echinochloae*, *P. obscurata*, and *P. sacchari*) are maintained in BIOTEC Culture Collection, Thailand (BCC). Voucher specimens of the new species and other studied fungal permanent slides are deposited in the BIOTEC Bangkok Herbarium, Thailand (BBH). Drawings were made directly from slides using a compound microscope (Olympus BX50) equipped with a drawing tube.

Taxonomy

Periconia notabilis Chuaseehar., Somrith. & Boonyuen **sp. nov.** PLATE 1

MycoBank MB 815470

Differs from other *Periconia* species by its subspherical, pale brown to brown sheath around the septum at the regeneration point of the conidiophore.

TYPE: Thailand, Pathum Thani Province, NSTDA, 14°04′33″N 100°36′21″E, on decaying twig of *Delonix regia* (Hook) Raf. (*Leguminosae*), 14 Jul. 2011, C. Chuaseeharonnachai (**Holotype:** BBH 39402).

ETYMOLOGY: From the Latin *notabilis* (noteworthy), referring to the conspicuous sheath on the conidiophores.

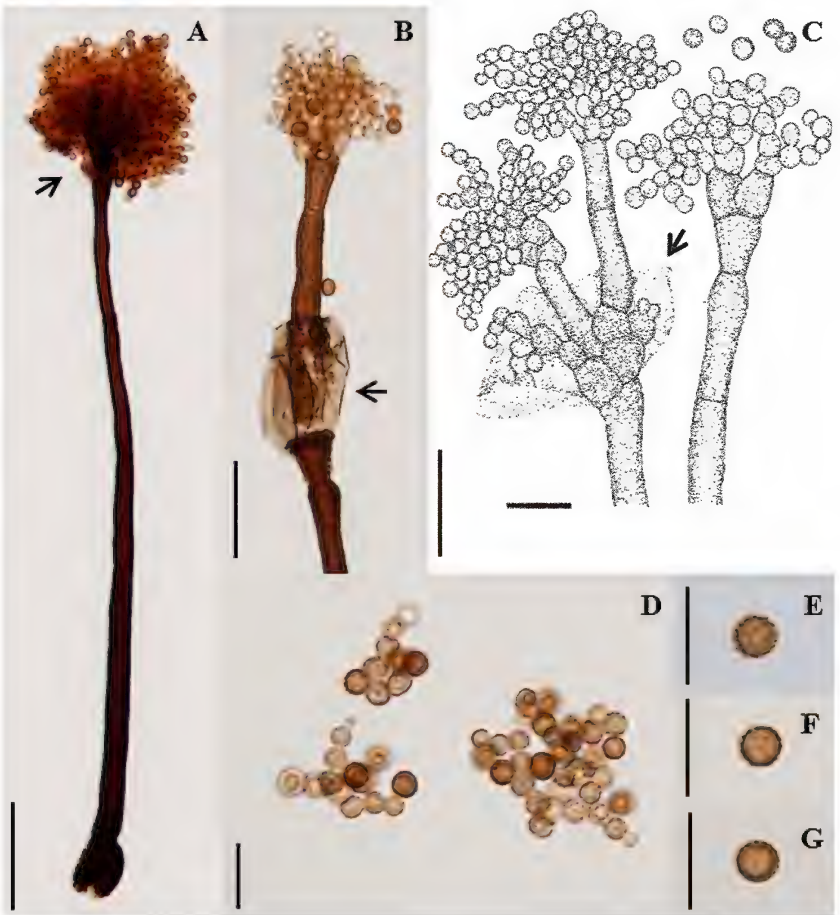


Plate 1. *Periconia notabilis* (holotype, BBH 39402). A. Conidiophores and head of conidia with sheath (arrow). B, C. Apical part of conidiophores showing sheath around the septa at the regeneration points (arrows), conidiogenous cells, and conidia. D. Branched chains of conidia formed blastically. E–G. Conidia. Scale bars: A = 50 µm; B, C = 25 µm; D–G = 10 µm.

Colonies on natural substrate effuse, dark, hairy. Mycelium mostly immersed. Conidiophores macronematous, mononematous, erect, 230–360 µm long, 10–20 µm thick at the base (x = 311 × 13.75 µm; n = 10), 5–7-septate, brown to reddish brown, thick-walled, verruculose especially below the apical conidial heads and smooth-walled at the basal part, often branched, and with regeneration. The primary branches are up to 15 × 7.5–10 µm; the secondary

branches are up to 10 × 7.5 µm, clavate-inflated, reddish brown, thick-walled, verruculose. Conidiophore regeneration is terminal and percurrent, leaving a subspherical, pale brown to brown, 30 × 22.5 µm diam. sheath. Conidiogenous cells monoblastic or polyblastic, discrete, subspherical to oval, smooth or verruculose, brown to reddish brown, arising directly from the apical cells of conidiophores, bearing simple or branched chains of conidia, 7.5–12.5 × 7.5 µm diam. Conidia catenate, spherical, pale brown to reddish brown, verruculose, aseptate, 3.5–5 µm diam. (x = 4.4 µm; n = 50).

Comment: *Periconia notabilis* resembles *P. minutissima* and *P. nigriceps* in having conidiophores with short branches at the apical head and having spherical verruculose conidia. However, *P. minutissima* differs by its conidiophore branches (at first adpressed like those of *P. notabilis* but later spreading) and by

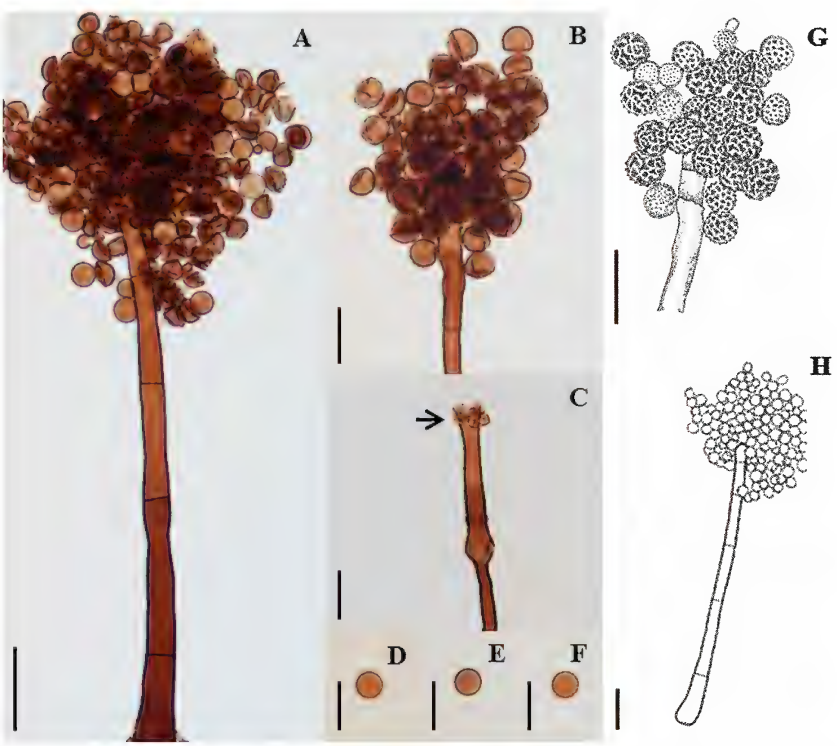


Plate 2. *Periconia byssoides* (BBH 39403). A, H. Conidiophores and head of conidia. B, G. Apical parts of conidiophores, conidiogenous cells, and conidia. C. Apical portion of conidiophore, arrow indicates a short apical cell cut off by a septum. D–F. Conidia. Scale bars: A, H = 50 µm; B–G = 25 µm.

its slightly larger (4–7 µm), straw-coloured to pale brown conidia (Ellis 1971); *P. nigriceps* differs by its smooth conidiophores and its larger conidia (6–8 µm; Earle 1902).

Periconia byssoides Pers., Syn. Meth. Fung.: 18 (1801) PLATE 2

COLONIES on natural substrate effuse, brown to dark brown, hairy. MYCELIUM mostly immersed, branched, septate, smooth, brown, 2.5 µm diam. CONIDIOPHORES macronematous, mononematous, erect, straight or slightly flexuous, 270–350 µm long, 15–17.5 µm thick at the base, 7.5 µm thick at the apex, unbranched, 4–5-septate, brown, thick-walled, verruculose immediately below the conidial heads and the lower to the basal part smooth-walled. CONIDIOGENOUS CELLS monoblastic or polyblastic, discrete, terminals, spherical, brown, smooth or verruculose. CONIDIA solitary or catenate, spherical, brown to reddish brown, verrucose, aseptate, 12.5–15 µm diam.

SPECIMEN EXAMINED: **THAILAND, KANCHANABURI PROVINCE,** Suan Pa Sai Yok, on decaying unidentified leaves, 22 Aug. 2012, C. Chuaseeharonnachai (BBH 39403).

COMMENT: *Periconia byssoides* resembles *P. manihoticola* and *P. shyamala* in having unbranched conidiophores with a short apical cell cut off by a septum and conidiogenous cells formed over apex in collar around the septum. However, conidia of *P. byssoides* are much smaller than those of *P. manihoticola* (25–45 µm) and *P. shyamala* (16–22 µm; Ellis 1971).

Periconia cookei E.W. Mason & M.B. Ellis, Mycol. Pap. 56: 72 (1953) PLATE 3

COLONIES on natural substrate effuse, brown to dark brown, hairy. MYCELIUM mostly immersed, branched, septate, smooth, brown, 2.5 µm diam. CONIDIOPHORES macronematous, mononematous, erect, straight or curved, 870–880 µm long, 20–22.5 µm thick at the base, 12.5 µm thick at the apex, unbranched, 4-septate, brown to reddish brown, thick-walled, verruculose immediately below the conidial heads and the lower to the basal part smooth-walled. CONIDIOGENOUS CELLS monoblastic or polyblastic, discrete, terminal, spherical, brown to reddish brown, smooth or verruculose. CONIDIA solitary or catenate, spherical, brown to reddish brown, verrucose, aseptate, 15–17.5 µm diam.

SPECIMENS EXAMINED: **THAILAND, CHIANG RAI PROVINCE,** Wiang Pa Pao District, on decaying leaves of *Artocarpus altilis* (Parkinson) Fosberg (*Moraceae*), 26 Oct. 2012, S. Somrithipol (BBH 35459, BCC 60881; BBH 35460, BCC 60882).

COMMENT: *Periconia cookei* (Ellis 1971) is morphologically similar to *P. jabalpurensis* and *P. guangdongensis* in having long unbranched conidiophores with a swollen apex. However, the verrucose conidia of *P. cookei*

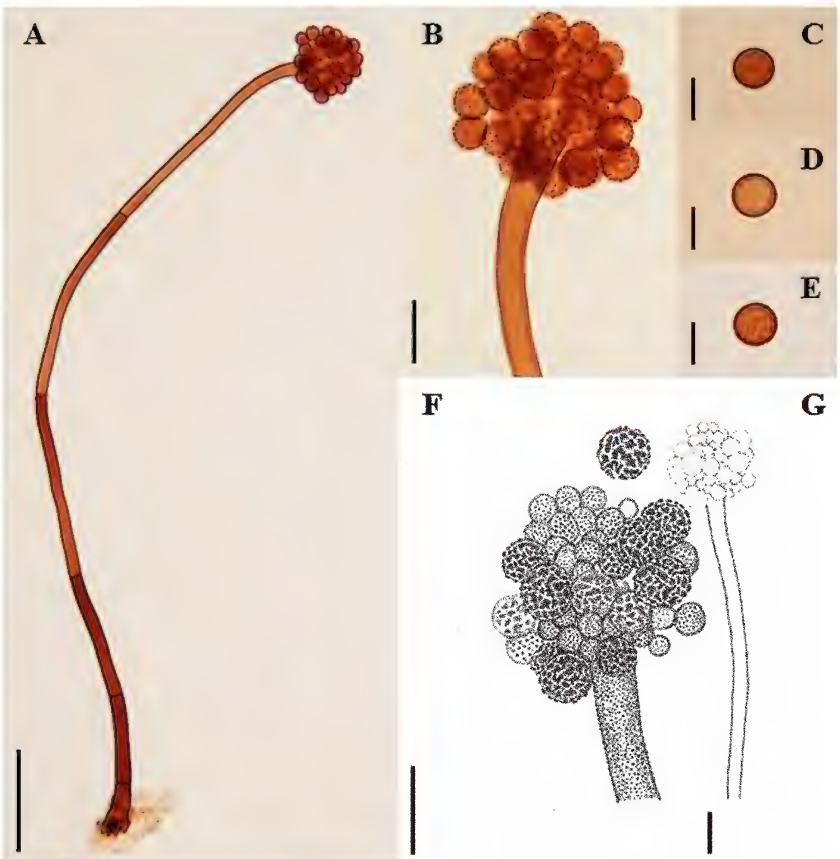


Plate 3. *Periconia cookei* (BBH 35460). A. Conidiophore and head of conidia. B, F, G. Conidiogenous cells and conidia. C–E. Conidia. Scale bars: A = 100 µm; B, F, G = 25 µm; C–E = 15 µm.

are larger than the echinulate conidia of *P. jabalpurensis* (8–12 µm; Ellis 1976) and *P. guangdongensis* (7–11 µm; Wu et al. 2015).

Periconia echinochloae (Bat.) M.B. Ellis, Demat. Hyphomyc.: 347 (1971) Plate 4

Colonies on natural substrate effuse, dark, hairy. Mycelium mostly immersed, branched, septate, smooth, brown. Conidiophores macronematous, mononematous, erect, straight or often curved, 540–800 µm long, 15–20 µm thick at the base, 7.5–10 µm thick at the apex, 7–8-septate, branched; always rising short lateral branches or formed in a group of 2–3 branches at the apex of the stipes with secondary and tertiary branches; the primary branches are up to

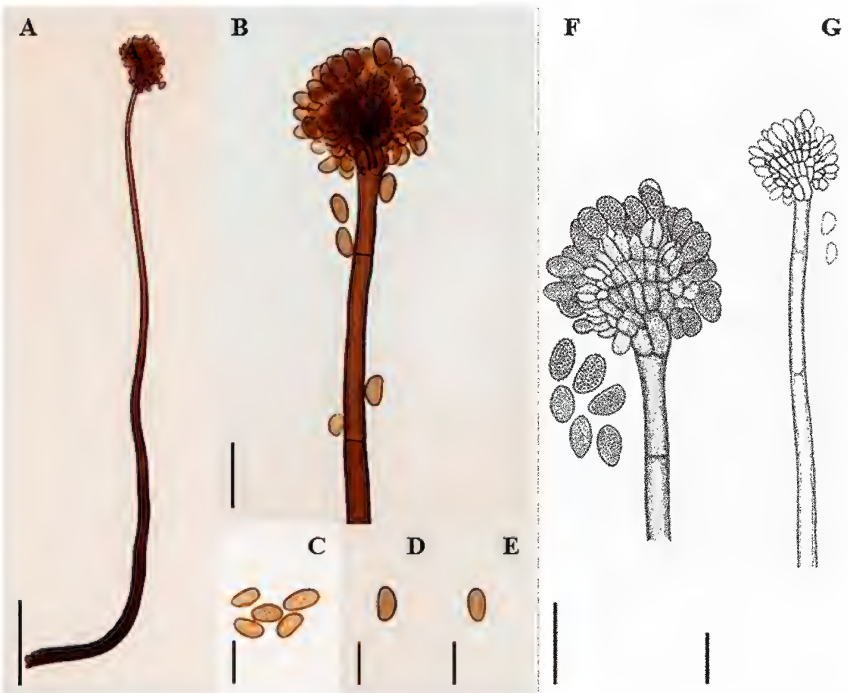


Plate 4. *Periconia echinochloae* (BBH 34960). A. Conidiophore and conidial head. B, F–G. Conidiogenous cells and conidia. C–E. Conidia. Scale bars: A = 100 μm; B, F–G = 25 μm; C–E = 15 μm.

30 × 6.25 μm; the secondary branches are up to 17.5 × 5 μm; the tertiary branches are 12.5 × 7.5 μm, brown to dark reddish brown toward the base, thick-walled, smooth, cylindrical, brown, thick-walled, smooth. Conidiogenous cells monoblastic or polyblastic, integrated, terminal, discrete, oval to cylindrical, brown to reddish brown, smooth. Conidia solitary, ellipsoidal to cylindrical, brown, verruculose, aseptate, 10.5–15 × 7.5–8.75 μm diam.

Specimens examined: **THAILAND, Pathum Thani Province,** NSTDA, on decaying leaves of *Saccharum officinarum* L. (*Poaceae*), 28 Aug. 2012, S. Somrithipol (BBH 34960, BCC 62335; BBH 34961, BCC 60844; BBH 34962, BCC 60845); Thanyaburi District, on decaying leaves of *Cymbopogon citratus* (DC.) Stapf (*Poaceae*), 27 Aug. 2012, S. Somrithipol (BBH 35457, BCC 60879).

Comment: *Periconia echinochloae* (Ellis 1971) is morphologically similar to *P. trachycarpicola* in having branched conidiophores and ellipsoidal conidia, but *P. trachycarpicola* has smaller conidia (6–11× 5–7 μm; Taylor & Hyde 2003).

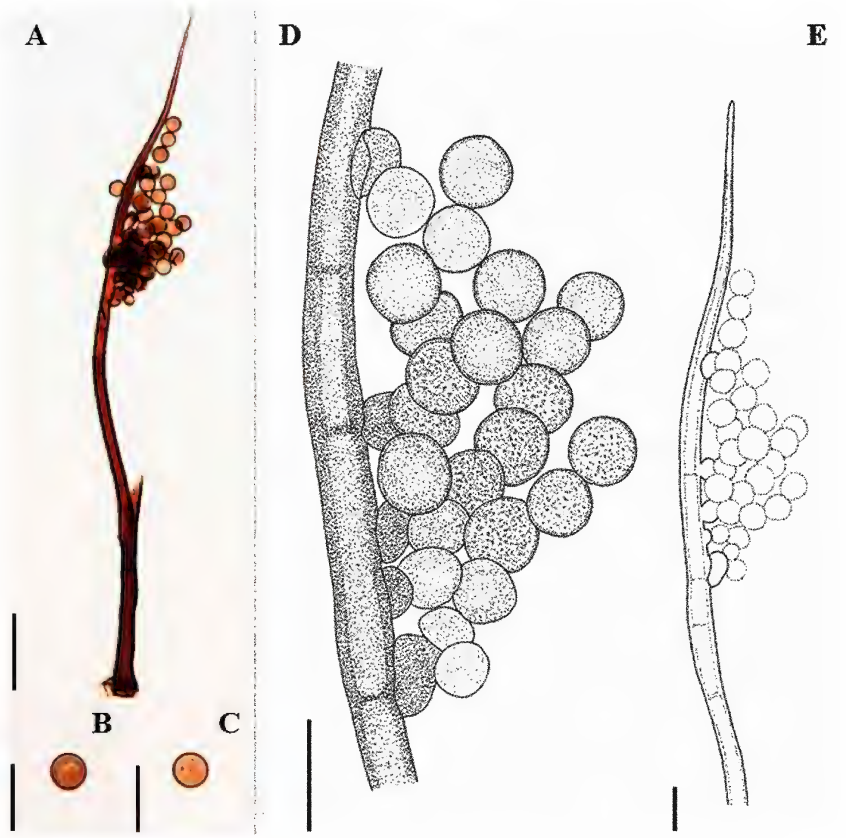


Plate 5. *Periconia lateralis* (BBH 36934). A. Conidiophore, conidiogenous cells, and conidia. B, C. Conidia. D, E. Conidiogenous cells and conidia. Scale bars: A = 50 µm; B–E = 20 µm.

Periconia lateralis Ellis & Everh., J. Mycol. 2: 104 (1886) Plate 5

Colonies on natural substrate effuse, brown to dark brown, hairy. Mycelium mostly immersed, branched, septate, smooth, brown. Conidiophores macronematous, mononematous, with setiform apices, erect, often curved, 300–440 µm long, 17.5–20 µm thick at the base, tapering to 2.5–5 µm at the apex, unbranched, 6–9 septate, brown to reddish brown toward the base, thick-walled, smooth. Conidiogenous cells monoblastic or polyblastic, discrete, directly formed in the middle part of the conidiophores, unilateral, spherical to oval, brown to reddish brown, smooth. Conidia solitary or catenate, spherical, brown, verruculose, aseptate, 10.5–15 µm diam.

Specimen examined: **THAILAND, Pathum Thani Province**, Thanyaburi District, on decaying leaves of *Brachiaria mutica* (Forssk.) Stapf (*Poaceae*), 27 Aug. 2012, S. Somrithipol (BBH 36934).

Comment: Morphologically, *P. lateralis* (Ellis 1971, Ellis & Everhart 1886) most closely resembles *P. fusiformis* and *P. pseudolateralis* in having solitary conidiophores with conidiogenous cells formed below the setiform apices. These species are otherwise distinguished by the branching system of conidiophores, the position of the conidiogenous cells, and conidial morphology. Conidiophores of *P. pseudolateralis* consist of fertile branches spirally arranged around the stipe, and the conidia are spiny and smaller (6–9 µm; Hoog & Rao 1975). The conidiophores of *P. fusiformis* consist of

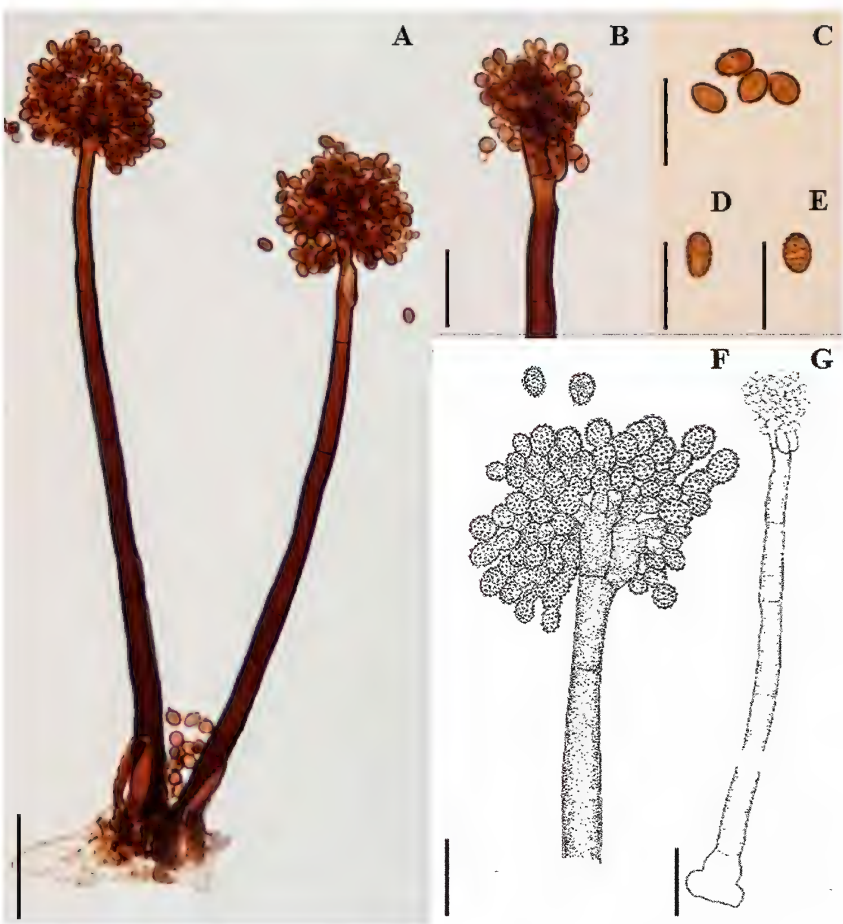


Plate 6. *Periconia obscurata* (BBH 39404). A. Conidiophores and conidial head. B, F. Conidiogenous cells and conidia. C–E. Conidia. F, G. Conidiophore, conidiogenous cells, and conidia. Scale bars: A, G = 50 µm; B, F = 25 µm; C–E = 20 µm.

fertile branches formed on all sides of the stipe, and the conidia are verrucose and smaller (9.5–13 µm; Muntañola-Cvetković et al. 1998).

Periconia obscurata Kirschst., Ann. Mycol. 34: 195 (1936) PLATE 6

COLONIES on natural substrate effuse, dark brown, hairy. MYCELIUM mostly immersed, branched, septate, smooth, brown, 5 µm diam. CONIDIOPHORES macronematous, mononematous, erect, straight or slightly flexuous, 200–350 µm long, 12–17.5 µm thick at the base, 7.5 µm thick at the apex, branched; usually rising short lateral branches at the apex, 4–6 septate, brown to dark brown toward the base, thick-walled, smooth. The apical branches are up to 20 × 6.25–7.5 µm, cylindrical, brown, thick-walled, smooth. CONIDIOGENOUS CELLS monoblastic or polyblastic, discrete, terminal, subspherical to oval, brown to dark brown, verruculose, 6.25–7.5 × 5–7.5 µm diam. CONIDIA solitary or catenate, ellipsoidal or oval, brown, verruculose, aseptate, 6.25–10 × 5–6.25 µm diam.

SPECIMEN EXAMINED: **THAILAND, KANCHANABURI PROVINCE,** Suan Pa Sai Yok, on decaying unidentified twig, 22 Aug. 2012, C. Chuaseeharonnachai (BBH 39404, BCC 61896).

COMMENT: *Periconia obscurata* is described here as a new record for Thailand. The morphological characters of our specimen are consonant with the description given by Kirschstein (1936) with the exception of length and branching of conidiophores. The conidiophores of Kirschstein's holotype were smaller (200–225 × 12–16 µm) and branching was not reported. This suggests that branching and length of conidiophores are not crucial characters to distinguish between species.

Periconia sacchari J.R. Johnst., J. Dept. Agric. Porto Rico 1: 225 (1917) PLATE 7

COLONIES on natural substrate effuse, dark brown, hairy. MYCELIUM mostly immersed, branched, septate, smooth, brown. CONIDIOPHORES macronematous, mononematous, erect, straight or slightly flexuous, 370–400 µm long, 17.5–20 µm thick at the base, tapering to 6.25–10 µm at the apex, branched; producing lateral branches or formed in a group of short 2–3 branches at the apex, 3–4-septate, brown to reddish brown toward the base, thick-walled, smooth. Branches mainly producing secondary, and tertiary branches; the primary branches are up to 92.5 × 5–6.25 µm; the secondary branches are 10–12.5 × 5 µm; the tertiary branches are 10 × 6.25 µm, cylindrical, brown, thick-walled, smooth. CONIDIOGENOUS CELLS monoblastic, discrete, terminal, ellipsoidal, brown to reddish brown, smooth, 10–12.5 × 5–7.5 µm diam. CONIDIA solitary, oblong, brown, verrucose, aseptate, 16.25–17.5 × 7.5–8.75 µm diam.

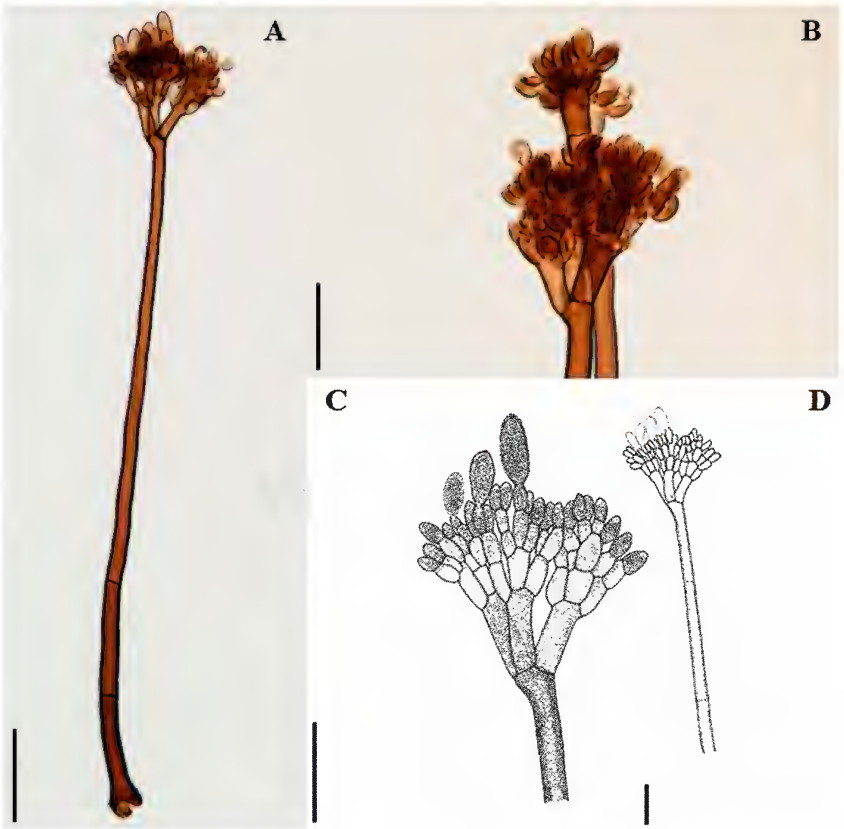


Plate 7. *Periconia sacchari* (BBH 35458). A. Conidiophore and conidial head. B–D. Conidiogenous cells and conidia. Scale bars: A = 50 μm; B–D = 25 μm.

Specimen examined: **THAILAND, Pathum Thani Province,** Thanyaburi District, on decaying leaves of *Cymbopogon citratus*, 27 Aug. 2012, S. Somrithipol (BBH 35458) – BCC 60880 culture in BCC.

Comment: *Periconia sacchari* (Ellis 1971) differs from other *Periconia* species in having oblong or cylindrical conidia. *Periconia nilagirica* also has elongate conidia, but they are echinulate, with a similar range of sizes but extending to a longer maximum (14–21 × 7–9.8 μm; Subramanian 1957, 1971).

Acknowledgments

The research was financed by National Center for Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA) with the grant number P–12–01294. The authors express our gratitude to Professor E.B. Gareth Jones at Department of Botany and Microbiology College of

Science King Saud University for his constructive review, critical reading and language corrections of the draft manuscript. Dr. Natapol Pornputtapong, a Postdoctoral Associate at Yale University, is acknowledged for his gathering supporting documents and references. We would like to thank Prof. Dr. Akira Nakagiri and Prof. Dr. R.F. Castañeda-Ruiz for their comments and suggestions for the improvement of the manuscript, and Dr. Shaun R. Pennycook for assistance with formatting the article.

Literature cited

Alias SA, Jones EBG. 2000. Colonization of mangrove wood by marine fungi at Kuala Selangor mangrove stand, Malaysia. Fungal Diversity 5: 9–21.

Cantrell SA, Hanlin RT, Emiliano A. 2007. *Periconia variicolor* sp. nov., a new species from Puerto Rico. Mycologia 99(3): 482–487. http://dx.doi.org/10.3852/mycologia.99.3.482

Earle FS. 1902. Mycological studies – I. Bulletin of the New York Botanical Garden 2: 331–350.

El-Sharouny HM, Gherbawy YAMH, Abdel-Aziz FA. 2009. Fungal diversity in brackish and saline lakes in Egypt. Nova Hedwigia 89: 437–450. http://dx.doi.org/10.1127/0029-5035/2009/0089-0437

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew.

Ellis JB, Everhart BM. 1886. New species of fungi from various localities. Journal of Mycology 2(9): 99–104. http://dx.doi.org/10.2307/3752230

Hoog GS de, Rao V. 1975. Some new hyphomycetes. Persoonia 8(2): 207–212.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth & Bisby's dictionary of the fungi. 10th edn. CAB International, Wallingford Oxon, UK.

Kirschstein W. 1936. Beiträge zur Kenntnis der Ascomyceten und ihrer Nebenformen besonders aus der Mark Brandenburg und dem Bayerischen Walde. Annales Mycologici 34(3): 180–210.

Kohlmeyer J. 1977. New genera and species of higher fungi from the deep sea (1615–5315 m). Revue de Mycologie 41(2): 189–206.

Markovskaja S, Kačergius A. 2014. Morphological and molecular characterisation of *Periconia pseudobyssoides* and closely related *P. byssoides*. Mycological Progress 13(2): 291–302. http://dx.doi.org/10.1007/s11557-013-0914-6

Muntañola-Cvetković M, Hoyo P, Gómez-Bolea A. 1998. *Periconia fusiformis* anam. sp. nov. Mycotaxon 68: 131–136.

Rao PR, Rao D. 1964. The genus *Periconia* from India. Mycopathologia et Mycologia Applicata 22(4): 285–310.

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS-KNAW Fungal Biodiversity Centre, Utrecht.

Subramanian CV. 1957. Hyphomycetes – IV. Proceedings of the Indian Academy of Sciences Section B 46: 324–335.

Subramanian CV. 1971. Hyphomycetes: an account of Indian species, except *Cercosporae*. Indian Council of Agricultural Research, New Delhi. 930 p.

Taylor JE, Hyde KD. 2003. Microfungi of tropical and temperate palms. Fungal Diversity Research Series 12. 459 p.

Tode HJ. 1791. Fungi Mecklenburgenses selecti. Fasc. II, Generum novorum appendicem, Lüneburg.

Whitton SR, McKenzie EHC, Hyde KD. 2012. Fungi associated with Pandanaceae. Fungal Diversity Research Series 21. 457 p. http://dx.doi.org/10.1007/978-94-007-4447-9_1

Wu Y-M, Xu J-J, Kong J-H, Zhang T-Y. 2015 ["2014"]. New species of *Graphium* and *Periconia* from China. Mycotaxon 129(2): 397–401. http://dx.doi.org/10.5248/129.397

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 503–509

http://dx.doi.org/10.5248/131.503

New host records of rust fungi (*Pucciniales*) from Pakistan

B. Ali, Y. Sohail & A.S. Mumtaz*

Department of Plant Sciences, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad, 45320, Pakistan

*Correspondence to: *asmumtaz@qau.edu.pk*

Abstract—*Uredopeltis chevalieri* on *Grewia optiva* and on *G. tenax* are new host records; *Broussonetia papyrifera on Cerotelium fici* and *Phakopsora ziziphi-vulgaris* on *Ziziphus spina-christi* are new host records for Pakistan; and within Pakistan *P. ziziphi-vulgaris* on *Ziziphus oxyphylla* is a new host record for the Islamabad region. An additional collection of *Phragmidium rosae-moschatae* on *Rosa centifolia* from Pakistan is described and illustrated.

Key words—Hazara Division, Margalla hills, Murree, *Uredinales*

Introduction

Pakistan is gifted with a rich and diverse flora with approximately 6000 species of wild plants, based on which the country has been divided into four phytogeographical regions: Irano-Turanian (46%), Sino-Himalayan (10%), Saharo-Sindian (9.5%), and Indian element (4.5%) (Hamayun 2003). About 400 species of rust fungi on 350 different host plant species have been reported in Pakistan (Ahmad et al. 1997). *Grewia tenax*, *Broussonetia papyrifera* and *Rosa centifolia* are exotic plants in Pakistan, while *Grewia optiva*, *Ziziphus spina-christi*, and *Z. oxyphylla* are native plants.

Both rust fungi and their host plants are still under-explored in Pakistan. In 2014 and 2015, fieldwork was carried out in different regions of the country to collect and investigate rust fungi and their hosts. Here we provide descriptions and illustrations including scanning electron micrographs of four new records of rust fungi.

Materials & methods

Different regions of Pakistan were surveyed for rust fungi in 2014–15. Collections of the infected plant material were preserved in the herbarium of Plant Sciences

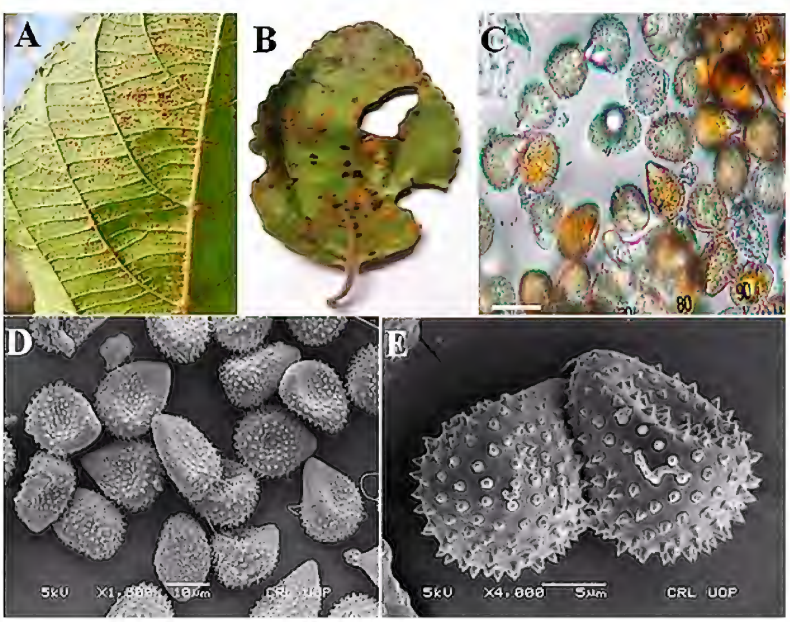
Department, Quaid-i-Azam University, Islamabad, Pakistan (ISL), and rust spores were mounted in glycerin jelly and fixed as semi-permanent slides. The spores were measured and photographed at 100× and 1000× magnifications under a Leitz HM-LU compound light microscope. At least 30 spores were measured for each spore stage, including the smallest and the largest spores found. Host plants were identified by comparing new collections with botanical specimens held in herb. ISL. Rust fungi were identified using the descriptions of McKenzie (1986), Walker & Shivas (2004), Sultan (2005), Berndt & Wood (2012), Afshan et al. (2012), Fiaz et al. (2015), and Yun (2016). For scanning electron microscopy the spores were scraped from the leaves, mounted on a stub, coated with gold in a sputter-coater, and examined with a JSM-5910 SEM.

New records

Uredopeltis chevalieri J. Walker & R.G. Shivas, Australas. Plant Path. 33: 43 (2004) PLATE 1

= *Phakopsora grewiae* (Pat. & Har.) Cummins, Bull. Torrey Bot. Club 72: 206 (1945)

SPERMOGONIA, AECIA, and TELIA not observed. UREDINIA mostly hypophyllous, scattered, about 1 mm in diam., reddish brown, subepidermal, paraphyses clavate, fused below and free above, incurved to irregular, hyaline to faintly yellowish, narrower at base. UREDINIOSPORES globose, subglobose to



Uredopeltis chevalieri. A. Abaxial leaf surface of *Grewia optiva* with brown uredinia. B. Adaxial leaf surface of *G. tenax* with brown uredinia and telia. C. Urediniospores on *G. tenax.* D, E. Scanning electron micrographs showing echinulate urediniospores with smooth bases. Scale bar: C = 10 µm.

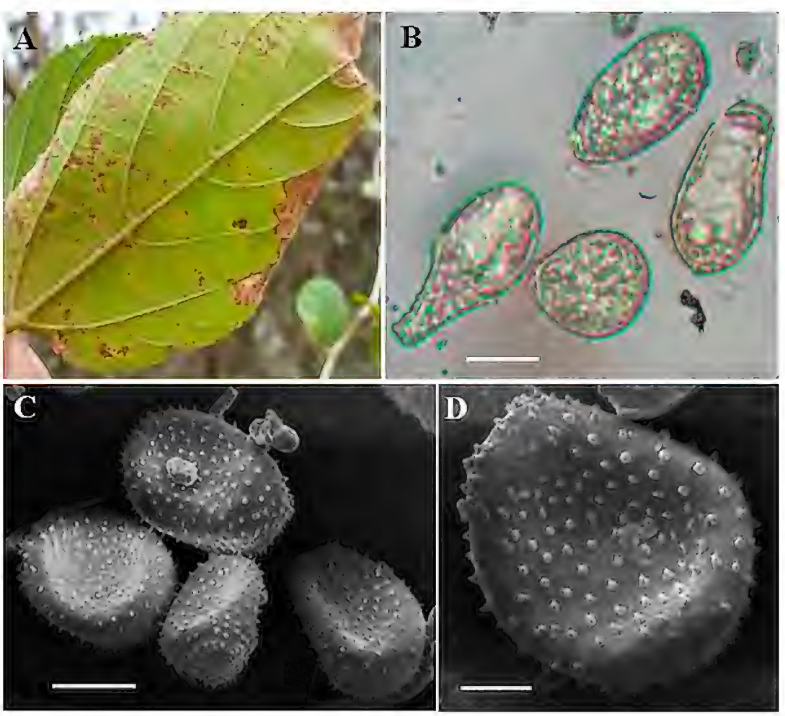
oval or pyriform, sometimes irregular, pale yellow to pale yellowish-brown or rarely hyaline, (18–)20–28(–31) × (15–)17–20(–22) µm in size, wall uniformly 1(–2) µm thick, echinulate, spores mostly with smooth bases, 4 equatorial germ pores.

Material examined—**PAKISTAN, Punjab**, Islamabad, Pir Sohawa, 823 m a.s.l., on *Grewia tenax* (Forssk.) Fiori, (*Malvaceae*), stage II, December 2014, B. Ali # BA60 (ISL-53522); on *G. optiva* J.R. Drumm. ex Burret, stage II, December 2014, B. Ali BA61 (ISL-29434); Islamabad, QAU, 595 m a.s.1., on *G. optiva*, stage II, December 2014, B. Ali BA22 (ISL-29435).

Comments—*Uredopeltis chevalieri* has been previously reported from Pakistan (as *Phakopsora grewiae*) on *Grewia asiatica* (Rahber-Bhatti et al. 1988, Ahmad et al. 1997). *Grewia optiva* and *G. tenax* are new host records for *U. chevalieri* worldwide.

Cerotelium fici (Castagne) Arthur, Bull. Torrey Bot. Club 44: 509 (1917) Plate 2

Spermogonia, aecia, and telia not observed. Uredinia hypophyllous, brown or pale brown, small, pulverulent, scattered, in groups, covered by



Cerotelium fici. A. Abaxial leaf surface of *Broussonetia papyrifera* with uredinia. B. Urediniospores C, D. SEM micrographs of finely echinulate urediniospores. Scale bars: B = 8 µm, C = 10 µm, D = 5 µm.

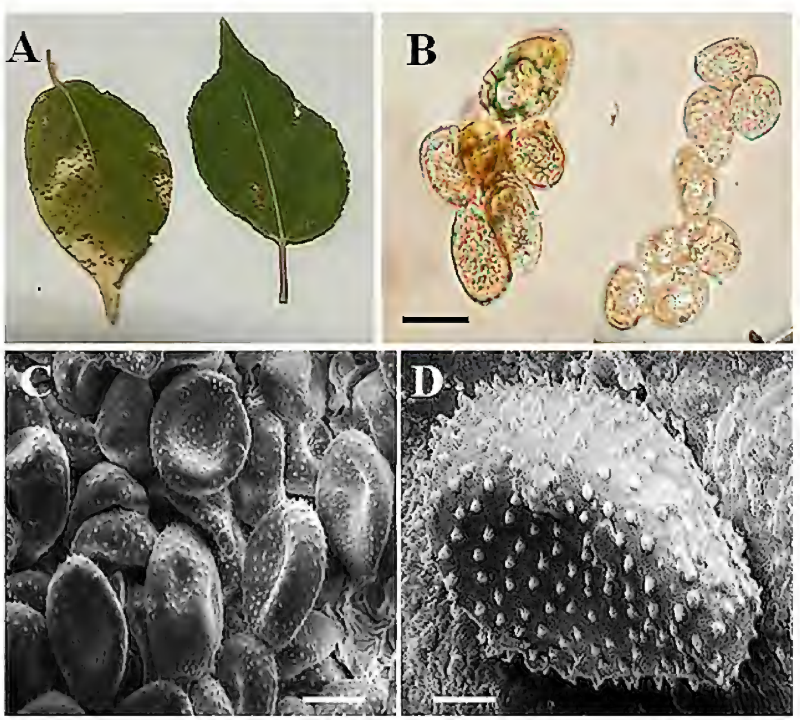
epidermis, surrounded by paraphyses. Urediniospores hyaline, ellipsoid, ovoid, elongated, subglobose, 26–36 × 14–22 µm in size, wall 1.5–2.5 µm thick, echinulate.

Material examined — **PAKISTAN, Khyber Pakhtunkhwa**, Hazara region, Haripur District, 538 m a.s.l., on *Broussonetia papyrifera* (L.) L'Hér. ex Vent. (*Moraceae*), stage II, December 2014, B. Ali # BA73 (ISL-114420).

Comments — *Cerotelium fici* has been previously described in Pakistan on *Ficus palmata*, *F. carica*, and *F. religiosa* (Ahmad 1956, Kaneko 1993, Iqbal & Khalid 1996, Ahmad et al. 1997, Fiaz et al. 2015). *Broussonetia papyrifera* is here recorded for the first time as a host of *C. fici* in Pakistan.

Phakopsora ziziphi-vulgaris Dietel, Ann. Mycol. 8: 469 (1910) Plate 3

Spermogonia, aecia, and telia not observed. Uredinia hypophyllous, in irregular groups, pale brown, pulverulent. Urediniospores globose to oval or

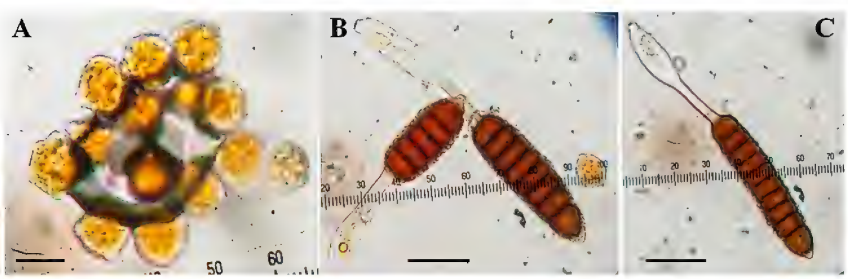


Phakopsora ziziphi-vulgaris A. Infected leaves of *Ziziphus oxyphylla*. B. Urediniospores on *Z. spina-christi*. C, D. SEM micrographs of echinulate urediniospores on *Z. spina-christi*. Scale bars: B = 10 µm, C, D = 15 µm.

obovoid, sometimes slightly irregular, pale brown to orange brown, 17.5–27.5 × 10–17.5 µm in size, wall 1.5–2.5 µm thick, echinulate, smooth areas in middle section of some spores.

Material examined — **Pakistan, Punjab Province,** Islamabad, Pir Sahwa, 823 m a.s.l., on *Ziziphus oxyphylla* Edgew. (*Rhamnaceae*), stage II, December 2014, B. Ali # BA49 (ISL-66410); Islamabad, QAU, 610 m a.s.l., on *Z. spina-christi* (L.) Desf., stage II, November-December 2014, B. Ali # BAH (ISL-66411).

Comments — *Phakopsora ziziphi-vulgaris* has been previously reported on *Ziziphus jujuba* from different regions of Pakistan (Ahmad 1956, Hasnain et al. 1959, Iqbal & Khalid 1996, Ahmad et al. 1997) and on *Z. oxyphylla* from Chakwal and Kallar Kahar (Kaneko 1993, Ahmad et al. 1997). Berndt & Wood (2012) recorded *Z. spina-christi* as a host of *P. ziziphi-vulgaris* in Israel. Here, *Z. spina-christi* is newly recorded from Pakistan as a host of *P. ziziphi-vulgaris*, and *Z. oxyphylla* represents a new host from the Islamabad region, Punjab.



Phragmidium rosae-moschatae. A. Urediniospores with yellowish contents. B. Teliospores with 5 and 8 cells. C. Teliospore with 10 cells. Scale bars: A = 10 µm, B, C = 50 µm.

Phragmidium rosae-moschatae Dietel, Hedwigia 44: 132 (1905) Plate 4

Spermogonia and aecia not observed. Uredinia hypophyllous, cinnamon brown, minute, rounded, scattered. Urediniospores 22–28 × 18–22 µm, globose to subglobose, single-celled, wall hyaline to yellow brown, 2–3 µm thick, coarsely verrucose, germ pores indistinct. Telia hypophyllous, black, minute, scattered. Teliospores 70–130 × 24–35 µm, cylindrical, rounded at both ends, deep brown to light brown, (5–)7–8(–10)-celled, wall dark brown to chestnut brown, 2–4 µm thick, with 2 germ pores, verrucose, with an apical papilla 7–13 µm in length, hyaline. Pedicel hyaline to olivaceous brown, 85–115 µm, at apex 8–10 µm thick, thickened to 14–25 µm at base, persistent, often with yellowish contents at base.

Material examined — **PAKISTAN, Khyber Pakhtunkhwa,** Muree, Ghora Gali, 1767 m a.s.l., on *Rosa centifolia* L. (*Rosaceae*), stages II+III, December 2014, B. Ali # BA22 (ISL-122345).

Comments — *Phragmidium rosae-moschatae* has been previously reported in Pakistan on *Rosa brunonii* [= *R. moschata*], *R. lacerans*, *R. webbiana*, and *R. centifolia* from Quetta, Murree, Peshawar, Tarnab, Swat, Kaghan Valley, and Tatu-Fairy Meadows in Pakistan (Malik & Khan 1944, Ahmad 1956, Jørstad & Iqbal 1967, Malik et al. 1968, Ono & Kakishima 1992, Ono 1992, Kakishima et al. 1993, Sultan 2005, Afshan et al. 2012). The number of cells in teliospores is variable: in the species protologue, Dietel (1905) described 5–10-celled teliospores; Pakistani teliospores have been described as (4–)7–8-celled by Jørstad & Iqbal (1967), as 5–7(–8)-celled by Sultan (2005) and Afshan et al. (2012), and as (5–)7–8(–10)-celled in this paper; and in a general modern description, Yun (2016) cited 5–7(–11)-celled teliospores.

Acknowledgements

We are sincerely thankful to Dr. Amy Rossman (Department of Botany and Plant Pathology, Oregon State University) and Dr. Merje Toome (Plant Health and Environment Laboratory, Ministry for Primary Industries, Auckland, New Zealand) for acting as presubmission reviewers and Dr. Shaun Pennycook (Auckland, New Zealand) for nomenclatural review and suggestions.

Literature cited

Afshan NS, Khalid AN, Niazi AR. 2012. Some new rust fungi (*Uredinales*) from Fairy Meadows Northern Areas, Pakistan. Journal of Yeast and Fungal Research 3: 65–73.

Ahmad S. 1956. Fungi of Pakistan. Biological Society of Pakistan, Lahore Monograph 1. 126 p.

Ahmad S, Iqbal SH, Khalid AN. 1997. Fungi of Pakistan. Sultan Ahmad Mycological Society of Pakistan, Dept. Bot. Univ. Punjab, Lahore, Pakistan. 248 p.

Berndt R, Wood AR. 2012. Additions to the rust fungi of South Africa. Mycological Progress 11: 483–497. http://dx.doi.org/10.1007/s11557-011-0764-z

Dietel P. 1905. Über die Arten der Gattung *Phragmidium*. Hedwigia 44: 112–132.

Fiaz M, Ahmad H, Afshan NS, Khalid AN. 2015. Some new records of *Uredinales* from Khyber Pakhtunkhwa, Pakistan. Mycotaxon 130: 569–575. http://dx.doi.org/10.5248/130.569

Hamayun M. 2003. Ethnobotanical studies of some useful shrubs and trees of District Buner, NWFP, Pakistan. Journal of Ethnobotanical Leaflets, Southern Illinois University, Carbondale IL, USA. 17 p. opensiuc.lib.siu.edu/cgi/viewcontent.cgi?article=1563&context=ebl

Hasnain SZ, Khan A, Zaidi AJ. 1959. Rusts and smuts of Karachi. Dept. Bot., Univ. Karachi, Monograph 2. 33 p.

Iqbal SH, Khalid AN. 1996. Material for the fungus flora of Pakistan. II. An updated check list of rust fungi (*Uredinales*) of Pakistan. Sultania 1: 39–67.

Jørstad I, Iqbal SH. 1967. Uredinales from West Pakistan. Nytt Magasin for Botanikk 14: 31–38.

Kakishima M, Izumi O, Ono Y. 1993. Rust fungi (*Uredinales*) of Pakistan collected in 1991. Cryptogamic Flora of Pakistan 2: 169–179.

Kaneko S. 1993. Parasitic Fungi on Woody Plants from Pakistan Himalaya. Cryptogamic Flora of Pakistan 2: 149–168.

Malik SA, Javaid MT, Ahmad M. 1968. *Uredinales* of Quetta-Kalat region of Pakistan. Biologia 14: 37–46.

Malik SA, Khan MA. 1944. Parasitic fungi of the North-West Frontier Province. Indian Journal of Agricultural Sciences 13: 522–527.

McKenzie EHC, 1986. New plant disease record in New Zealand: Fig rust (*Cerotelium fici*) on *Ficus carica*. New Zealand Journal of Agricultural Research 29: 707–710. http://dx.10.1080/00288233.1986.10430467

Ono Y, Kakishima M. 1992. *Uredinales* collected in the Swat Valley, Pakistan. Cryptogamic Flora of Pakistan 1: 197–216.

Ono Y. 1992. *Uredinales* collected in the Kaghan Valley, Pakistan. Cryptogamic Flora of Pakistan 1: 217–240.

Rahber-Bhatti MH, Memon MI, Shahani NM, Khuhro MA. 1988. Laboratory evaluation of some plants against rust. Pakistan Journal of Agricultural Research 9: 274–277.

Sultan MA. 2005. Taxonomic study of rust flora of Northern Areas of Pakistan. Ph.D. Thesis, University of the Punjab. Lahore, Pakistan.

Walker J, Shivas RG. 2004. *Uredopeltis chevalieri* sp. nov., the rust of *Grewia* (*Tiliaceae*) formerly known as *Phakopsora* (or *Dasturella*) *grewiae*, its first record in Australia and a summary of the known rusts of *Grewia*. Australasian Plant Pathology 33: 41–47.

Yun HY. 2016. Musk rose rust – *Phragmidium rosae-moschatae*. Systematic Mycology and Microbiology, ARS, USDA – Invasive and Emerging Fungal Pathogens – Diagnostic Fact Sheets. http://nt.ars-grin.gov/sbmlweb/fungi/diagnosticfactsheets.cfm [Retrieved 30 January 2016].

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 511–520

http://dx.doi.org/10.5248/131.511

New records of myxomycetes from México

Marcos Lizárraga[1], Gabriel Moreno[2*] & Martín Esqueda[3]

[1] *Dpto. Ciencias Químico Biológicas, Instituto de Ciencias Biomédicas, Univ. Autónoma de Ciudad Juárez, Anillo Envolvente Pronaf y Estocolmo s/n, Ciudad Juárez, Chihuahua 32300, México*

[2] *Dpto. Ciencias de la Vida, Edificio de Biología, Univ. Alcalá, 28805 Madrid, Spain*

[3] *Centro de Investigación en Alimentación y Desarrollo, A.C. Apartado Postal 1735, Hermosillo, Sonora, México*

* Correspondence to: *gabriel.moreno@uah.es*

Abstract—*Badhamia rhytidosperma*, *Didymium synsporon*, *Echinostelium coelocephalum*, *Perichaena polygonospora*, and *Physarum synsporum* are described in both macroscopic and microscopic detail and represent new records from Mexico.

Key words—*Amoebozoa*, chorology, myxobiota, slime moulds, taxonomy

Introduction

The present paper represents a contribution to a program of study on myxomycetes in Mexico that began 19 years ago and from which several publications have been generated. Most of the latter have been compiled into Mexico's myxomycete inventory by Moreno et al. (2007). In this paper, we present new records of several species that are poorly known worldwide and thus are scarcely referenced in the specialized literature regarding this group of organisms.

Materials & methods

The studied material was obtained from bark samples collected from living trees in several Mexican states (Chihuahua, Mexico City, and Sinaloa) and placed in more than 200 moist chambers. Only species identified as new records for the Mexican myxobiota are reported here.

Spores (including surface structures such as spines or warts) were measured with an oil immersion lens. Light microscopy (LM) was carried out with a Nikon microscope equipped with an automatic photographic system. SEM micrographs were produced with a Zeiss DSM-950 microscope. For ultramicroscopic studies, material was rehydrated in concentrated (28–30%) ammonium hydroxide for 30 min, dehydrated in aqueous ethanol (70%) for 30 min, fixed for 2 h in pure ethylene glycol dimethyl ether (= 1,2–dimethoxymethane), and finally immersed in pure acetone for at least 2 h. This was followed by critical point drying and sputtering with gold-palladium. This technique allows the use of very little material (i.e., part of a single sporocarp or sometimes no more than a few spores).

Specimens are conserved in the herbarium of the Life Sciences Department (Botany), University of Alcalá, Madrid, Spain (AH) with a duplicate of some specimens deposited in the Fungi Collection of Biomedical Sciences Institute, Autonomous University of Ciudad Juárez, México (UACJ). Permanent slides were prepared with Hoyer's liquid for microscopic study.

Taxonomy

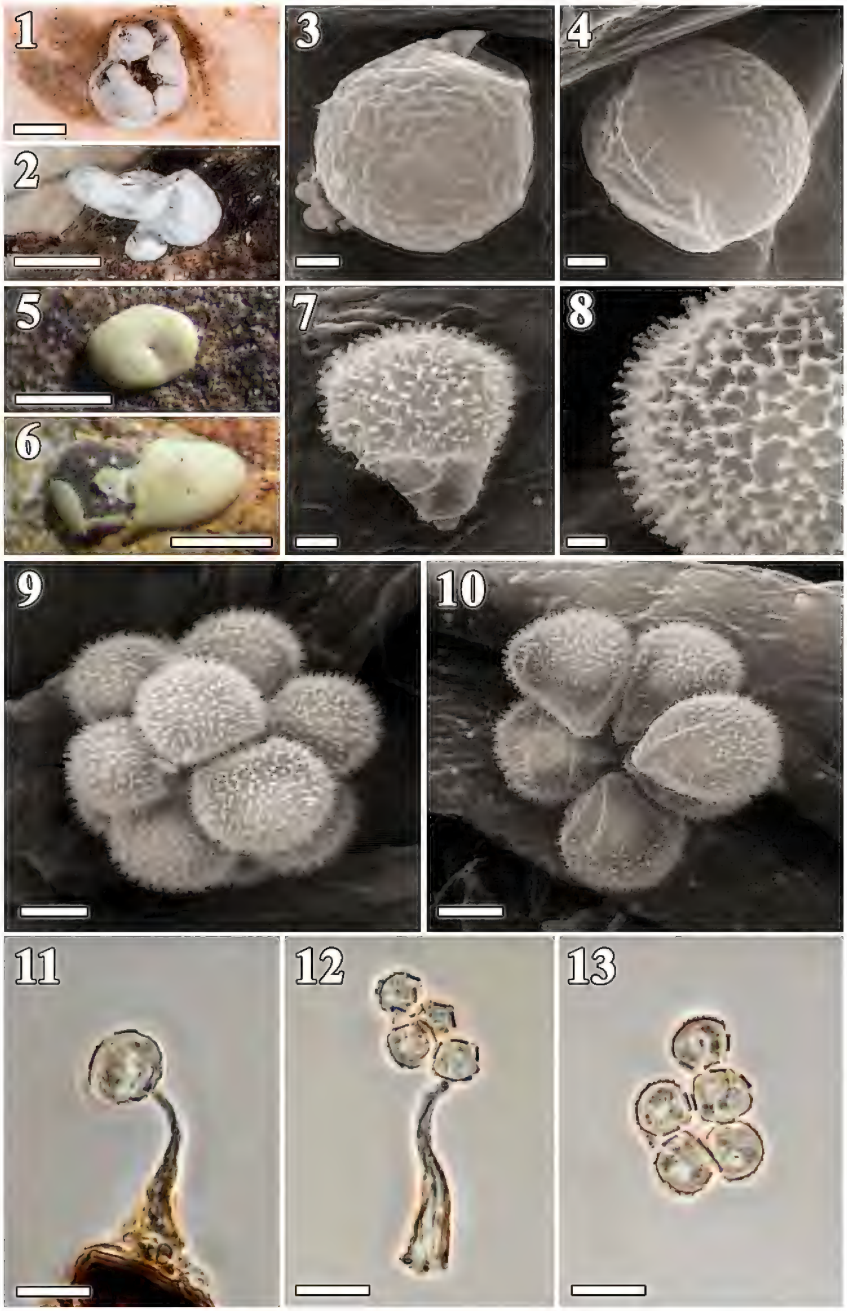
Badhamia rhytidosperma H.W. Keller & Schokn., Mycologia 81: 783 (1989) Figs 1–4

Fructifications sessile white plasmodiocarps. Sporotheca globose, subglobose to lobular with gyrose-confluent irregular lobes of 0.4–0.6 × 0.7–1.0 mm. Peridium double, calcareous external layer smooth to slightly rough, internal layer membranous with irregular dehiscence. Hypothallus inconspicuous. Capillitium physaroid or more rarely badhamioid, formed by joined filaments through elongated to irregular calcareous nodules. When the capillitium is badhamioid a pseudocolumella appears at the center of sporotheca, which is thick, irregular and calcareous. Spores (10–)12–14(–15) µm diam., black in mass and violaceous under LM, globose to subglobose, surface smooth over one half of the spore but markedly reticulate over the other half. Under SEM a reticulate ornamentation is confirmed in one side and smooth on the opposite side with a distinct ridge or additional lines as indicated by Keller & Schoknecht (1989).

Specimen examined: **MEXICO, Chihuahua:** Biomedical Sciences Institute gardens, Autonomous University of Ciudad Juárez, on bark of *Morus nigra* L., 5 February

---

Figs 1–13. ***Badhamia rhytidosperma*** (AH 45861). 1, 2. Plasmodiocarps. 3. Spore showing the reticulate wall as observed by SEM. 4. Spore showing a smooth area with adjacent ridge by SEM. ***Didymium synsporon*** (AH 45866). 5. Sporocarp. 6. Plasmodiocarp. 7. Spore with bacula outside and smooth inside by SEM. 8. Details of bacula with a verrucose apex and reticulate base by SEM. 9. Spore cluster by SEM. 10. Detail inside a spore cluster by SEM. ***Echinostelium coelocephalum*** (AH 45867). 11. Spore-like body with thick articulate surfaces. 12, 13. Spores with thick articulate surfaces and regular thickness at contact points between spores. Scale bars: 1, 2, 5, 6 = 0.5 mm; 3, 4, 7 = 2 mm; 8 = 1 µm; 9, 10 = 5 µm.


1
2
3
4
5
6
7
8
9
10
11
12
13

2000, leg. M. Lizárraga; obtained from moist chamber 21 February 2000 (UACJ 190, AH 45861).

Additional specimen examined: ***Badhamia spinispora***: MEXICO, Sonora: El Pinacate y Gran Desierto de Altar biosphere reserve, on bark of *Parkinsonia* sp., 18 February 2012, leg. M. Lizárraga; obtained from moist chamber 16 March 2012 (AH 45862).

Habitat & distribution—*Badhamia rhytidosperma* has been described previously from two field collections on alfalfa remnants from the type locality (Kansas, USA) and from moist chamber cultures prepared with cow dung (Keller & Schoknecht 1989). The specimen (AH 45862) from Sonora, Mexico, recorded originally as *B. rhytidosperma* by Esqueda et al. (2013) is here redetermined as *B. spinispora*. Consequently our Chihuahua specimen represents the first authentic Mexican record of *B. rhytidosperma*.

Observations—*Badhamia rhytidosperma* is morphologically similar to *Badhamia spinispora* (Eliasson & N. Lundq.) H.W. Keller & Schokn., *B. verrucospora* G. Moreno et al., and *Physarum apiculosporum* Härk. from which it is clearly distinguished by its spore ornamentation. Spores are spiny in *B. spinispora,* verrucose in *B. verrucospora*, and smooth in *P. apiculosporum* (Moreno et al. 2011), whereas *Badhamia rhytidosperma* has globose spores in which half of the spore is smooth and the other is reticulate. On its surface, a crested conspicuous line is observed at the site where the spore germinates (Fig 4). Based on the literature, only the type material described by Keller & Schoknecht (1989) was previously known.

Didymium synsporon T.E. Brooks & H.W. Keller, Mycologia 65: 287 (1973)

Figs 5–10

Fructifications sessile, sporocarpic, or (more rarely) plasmodiocarpic, ranging from pulvinate to flat and occasionally umbilicate, 0.3–1 × 0.1–0.8 mm, whitish to grey-white. Peridium formed by two joined layers, the external layer crust-like (similar to an eggshell) and the inner layer membranous and translucent. A columella was not observed. Capillitium is formed by rigid and parallel filaments arising from the sporocarp base towards its apex; the ends are dichotomous or bifurcate with few transversal junctions, dark to hyaline at apex of 1–3(–4) µm diam. and few enlargements. Spores dark in mass and violaceous under LM, in clusters of 8–20, 10–12 µm diam., pyriform to subglobose, conspicuous ornamentation formed by fused warts that provide a reticular to subreticular aspect, the ornamentation becoming less dense (formed of small sparse warts) toward the base where attached to other spores. Under SEM, the spore ornamentation is formed by bacula with a verrucose apex and reticulate base.

Specimens examined: **MEXICO, Chihuahua:** Cumbres de Majalca, on bark of *Juniperus* sp., 22 September 2003, leg. M. Lizárraga; obtained from moist chamber 29 September 2003 (UACJ 493); obtained from moist chamber 30 September 2003 (UACJ 466); obtained from moist chamber 1 October 2003 (UACJ 504, AH 45865); obtained from moist chamber 8 October 2003 (UACJ 470); 8 August 2014, leg. M. Lizárraga; obtained from moist chamber 14 August 2014 (AH 45866).

Habitat & distribution—*Didymium synsporon* was first described in the United States from bark sampled from living *Juniperus virginiana* L., cultured in moist chambers, and there are limited records in the United States (Arkansas, Kansas, Kentucky, and Tennessee; Keller & Brooks 1973). The species was also observed from a collection made on *Opuntia* sp. from Atacama, Chile (Lado et al. 2007).

Observations—This species is distinguished by its crust-like external peridium, spore clusters, and a capillitium formed by rigid parallel filaments rising from the sporocarp base towards the apex. It is the only known *Didymium* species with clustered spores.

Echinostelium coelocephalum T.E. Brooks & H.W. Keller, Mycologia 68: 1212 (1977) ["1976"]. Figs 11–13

Sporocarps isolated to gregarious, stipitate, 45–60 µm total height, whitish to slightly yellow. Stipe 20–30 µm long, cylindrical and expanded towards the base to 4–6 µm diam., becoming thinner towards the apex of 1–1.5 µm diam. Sporotheca globose to subglobose, 20–30 µm diam., white to slightly yellow. Capillitium absent. Peridium persistent, similar to a thick collar at columella base of 5–8 µm diam. Spores hyaline in mass and whitish to yellowish under LM, globose to subglobose, 7–10 µm diam., faintly verrucose with thick articulate surfaces and regular thickness, c. 1 µm thick at contact point between spores.

Specimen examined: **MEXICO, Chihuahua:** Cumbres de Majalca, on bark of *Quercus* sp., 15 November 2003, leg. M. Lizárraga & G. Mendoza; obtained from moist chamber 6 May 2004 (UACJ 605, AH 45867).

Habitat & distribution—*Echinostelium coelocephalum* was described from Arkansas in the United States from bark samples collected in different American states and cultured in moist chambers (Keller & Brooks 1977). It has since been reported from Argentina (Lado et al. 2014), Australia (Davison et al. 2008), Belize (Lado et al. 2008), France (Mitchell et al. 1984), New Caledonia (Kylin et al. 2013), the Republic of South Africa (Ndiritu et al. 2009), Spain (Pando 1989), U.S.A. (Haskins et al. 2000), and Kazakhstan, Ukraine, Tunisia, and Turkey (Discover Life 2015). It is possibly an extensively distributed species that has been overlooked because of its small size and resemblance to other similar species.

Observations—Characterized by its small size and articulate spores with evenly thick walls, *E. coelocephalum* may be confused with *E. colliculosum* K.D. Whitney & H.W. Keller, which differs by its larger fructifications (70–150 µm) and spores with narrow articulations. Haskins & McGuinness (1986) examined the microwarts on the spore surface of *E. coelocephalum* under the SEM, and Haskins et al. (2000) investigated heterothallic mating systems in this species.

Perichaena polygonospora Novozh., Zeml., Schnittler & S.L. Stephenson, Mycologia 100: 819 (2008) Figs 14–19

Sporocarps sessile, isolated to gregarious. Sporotheca very small, 0.1–0.15 mm diam., globose to subglobose, yellow-orange to dark yellow. Peridium simple and membranous, frequently appearing as externally ornamented with dark-brown small protrusions or warts homogenously distributed on its surface and composed of granulated material; inner surface smooth under LM. Dehiscence irregular. Capillitium absent. Spores yellowish in mass and bright yellow under LM, (10–)11–12(–13) µm diam., globose to subglobose, polyhedral, verrucose. The polyhedral morphology of the verrucose spores and its well-defined smooth angles were confirmed under SEM. Spore ornamentation consists of fused bacula that form pyramidal structures of different sizes and thickness.

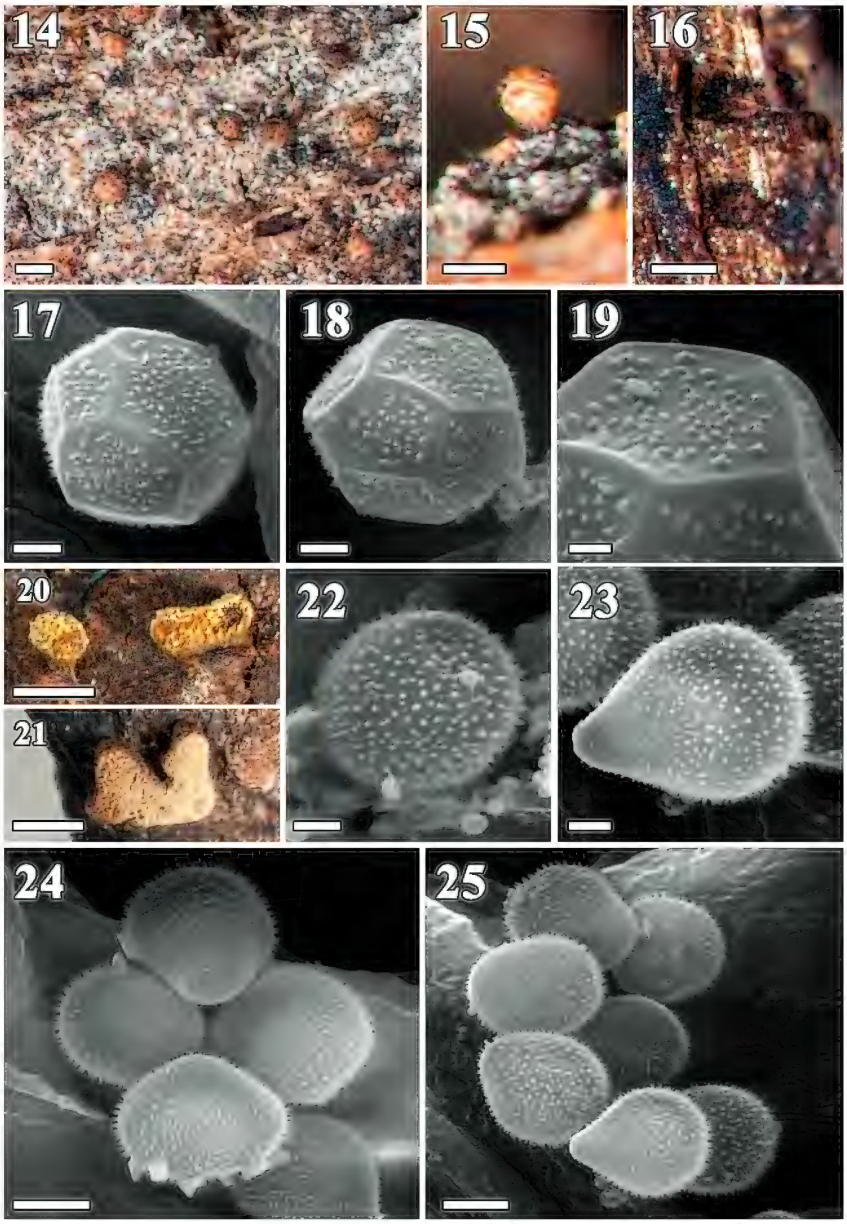
Specimens examined: **MEXICO, Mexico City:** Bosque de Chapultepec, on bark of *Taxodium mucronatum* Ten., 30 March 2015, leg. M. Lizárraga; obtained from moist chamber 16 May 2015 (AH 45868); obtained from moist chamber 3 June 2015 (AH 45869); obtained from moist chamber 11 June 2015 (AH 45870).

Habitat & distribution—*Perichaena polygonospora* fruits on litter and small twigs of shrubs but also on weathered herbivore dung (Novozhilov et al. 2008). Studied specimens were collected from New Mexico (United States) on elk dung (*Cervus canadensis*) (Mitchell & Moreno 2013) from Mexico City on bark of *Taxodium mucronatum*. This species was originally described in Russia and Kazakhstan by Novozhilov et al. (2008) and recorded and described later in the United States by Mitchell & Moreno (2013).

Observations—*Perichaena polygonospora* is characterized by its minute (0.1–0.15 mm diam) globose sporotheca, generally with dark brown protrusions attached to the peridium, irregular dehiscence, polyhedral spores, and lack of a capillitium. A similar species, *Licea eremophila* D. Wrigley et al., also has similarly sized [(9–)10–12(–13) µm diam] polyhedral spores but can

---

Figs 14–25. ***Perichaena polygonospora*** (AH 45870, except for Figs 14, 15). 14. Gregarious sporocarps (AH 45557). 15. Sporocarp detail (AH 45557). 16. Peridium with small warts dark-brown. 17, 18. Polyhedral spores by SEM. 19. Detail of spore ornamentation by SEM. ***Physarum synsporum*** (AH 45557, except for Fig. 20). 20. Fructifications sporangiate to plasmodiocarpic



(AH 45872). 21. Branched sporotheca. 22. Spore with bacula on the outside by SEM. 23. Spore with bacula on the outside and smooth on the inner surface by SEM. 24. Spore cluster by SEM. 25. Detail of an internal spore cluster by SEM. Scale bars: 14–16 = 100 µm; 17, 18, 22, 23 = 2 µm; 19 = 1 µm; 20, 21 = 0.5 mm; 24, 25 = 5 µm.

be distinguished by its stipitate sporotheca, a peridium formed by plates, and its habitat on dead leaf bases of the bromeliad *Puya* spp. and dead remains of the cacti *Trichocereus* sp. and *Miqueliopuntia miquelii* (Monv.) F. Ritter from Argentina and Chile (Wrigley de Basanta et al. 2010).

Perichaena polygonospora belongs to the *Perichaena* group that lacks a capillitium and includes such species as *P. pachyderma* D.W. Mitchell et al., which also fruits on herbivore dung (deer, elk, and cow) but differs by its globose, verrucose, non-polyhedral spores (10–11(–12) µm diam.; Mitchell et al. 2011).

Physarum synsporum S.L. Stephenson & Nann.-Bremek., Proc. Kon. Ned. Akad. Wetensch., C. 93:193 (1990) FIGS 20–25

FRUCTIFICATIONS solitary to gregarious, sporangiate to plasmodiocarpic, sessile. SPOROTHECA subglobose, flat and somewhat branched, 0.3–1.5 × 0.3–0.5 mm, yellowish to grey-yellowish. PERIDIUM simple and calcareous, superficially granulated due to calcium carbonate nodules lifting the peridium. Dehiscence irregular. CAPILLITIUM formed by a calcareous nodule network that ranges from subglobose to fusiform, whitish and joined by small hyaline filaments. SPORES dark brown in mass and violaceous brown under LM, 10–12 µm diam., in clusters consisting of 4–8 pyriform, turbinate to subglobose spores that are easily dispersed; the surface superficially verrucose on the spore base but becoming less dense (small sparse warts) closer to the attachment zone with the next spore. SEM confirms the turbinate morphology and reveals an ornamentation composed of abundant bacula outside but very scarce and smaller to almost absent inside. No plasmodium was observed.

SPECIMENS EXAMINED: **MEXICO, SINALOA:** Culiacán, Colonia Guadalupe Victoria, on bark of *Mangifera indica* L., 20 February 2013, leg. M. Lizárraga; obtained from moist chamber 5 September 2014 (AH 45871); obtained from moist chamber 1 October 2014 (AH 45872).

HABITAT & DISTRIBUTION—*Physarum synsporum* was described in the United States based on material appearing on samples of *Juniperus virginiana* in a moist chamber. Subsequently, it has been reported only on shrub twigs in Argentina (Lado et al. 2011).

OBSERVATIONS—The diagnostic characters of *P. synsporum* are the plasmodiocarpic to sporocarpic fructifications with a yellowish and strongly granulated peridium as well as clustered spores, which are easily dispersed, allowing the observation of its pyriform or turbinate shapes with their marked ornamentation at the external portion of the spore.

Physarum lakhanpalii Nann.-Bremek. & Y. Yamam., a species difficult to characterize, is distinguished by its plasmodiocarpic yellowish fructifications,

yellow carbonate calcium nodules, and subglobose (11–12.5 µm diam.) densely verrucose spores in clusters of 4–6 (Nannenga-Bremekamp & Yamamoto 1987); because the protologue does not indicate the distribution of the verrucae, we assume that they are homogeneously distributed all along the edge of the spore.

Shortly after the publication of *P. lakhanpalii,* a second species with clustered spores (*P. synsporum*) was described that is characterized by dark-brown plasmodiocarpic fructifications, whitish calcium carbonate nodules, and clusters of 3–8 subglobose to turbinate spores (12–13 µm diam), smooth or displaying few small warts on the inside (Stephenson & Nannenga-Bremekamp 1990). These authors separate *P. synsporum* from *P. lakhanpalii* by its capillitium with whitish nodules and its turbinate spore clusters with warts obvious only on the external area.

The specimens from Mexico correlate well microscopically with the description of *P. synsporum*, although the fructification has a yellowish color instead of dark-brown as originally described. According to our experience, as this species was obtained from a moist chamber, it probably did not optimally develop the peridium pigmentation. *Physarum decipiens* M.A. Curtis is very similar to *P. synsporum*, differing only in the absence of clustered spores.

Acknowledgements

We wish to express our gratitude to Mr. A. Priego and Mr. J. A. Pérez of the Electron Microscopy Service of the University of Alcalá de Henares for their invaluable help with the SEM. We also thank L. Monje and A. Pueblas of the Department of Drawing and Scientific Photography at the Alcalá University for their help in the digital preparation of photographs and to Dr. J. Rejos, curator of the AH herbarium for his assistance with the specimens examined in the present study. We want to express our gratitude to S.L. Stephenson and J.R. Deschamps for reviewing the manuscript. M. Lizárraga extends thanks to Dr. Alejandro Martínez of Dpto. Ciencias Químico Biológicas, Universidad Autónoma de Ciudad Juárez, for economic support.

Literature cited

Davison EM, Davison PJN, Brims MH. 2008. Moist chamber and field collections of myxomycetes from the northern Simpson Desert, Australia. Australasian Mycologist 27: 129–135.

Discover Life. 2015. http://www.discoverlife.org/ [accessed 1.XII.2015].

Esqueda M, Coronado ML, Gutiérrez A, Lizárraga M, Raymundo T, Valenzuela R. 2013. Hongos de reserva de la biosfera El Pinacate y Gran Desierto de Altar. CIAD. Hermosillo, Sonora, México. 107 p.

Haskins EF, McGuinness MD. 1986. Comparative ultrastructural observations of spore wall structure in six species of *Echinostelium* and three species of *Eumycetozoa*. Mycologia 78: 613–618. http://dx.doi.org/10.2307/3807774

Haskins EF, McGuinness MD, Clark J. 2000. Heterothallic mating systems in the *Echinosteliales* II. *Echinostelium coelocephalum*. Mycologia 92: 1080–1084. http://dx.doi.org/10.2307/3761475

Keller HW, Brooks TE. 1973. Corticolous myxomycetes I: two new species of *Didymium*. Mycologia 65: 286–294. http://dx.doi.org/10.2307/3758101

Keller HW, Brooks TE. 1977 ["1976"]. Corticolous myxomycetes V: observations on the genus *Echinostelium*. Mycologia 68: 1204–1220. http://dx.doi.org/10.2307/3758753

Keller HW, Schoknecht JD. 1989. Spore-to-spore cultivation of a new wrinkled-reticulate-spored *Badhamia*. Mycologia 81: 783–789. http://dx.doi.org/10.2307/3759883

Kylin H, Mitchell DW, Seraoui El-H, Buyck B. 2013. Myxomycetes from Papua New Guinea and New Caledonia. Fungal Diversity 59: 33–44. http://dx.doi.org/10.1007/s13225-012-0180-y

Lado C, Estrada-Torres A, Stephenson SL. 2007. Myxomycetes collected in the first phase of a north-south transect of Chile. Fungal Diversity 25: 81–101.

Lado C, Wrigley de Basanta D. 2008. A review of neotropical myxomycetes (1828–2008). Anales del Jardín Botánico de Madrid 65(2): 211–254. http://dx.doi.org/10.3989/ajbm.2008.v65.i2.293

Lado C, Wrigley de Basanta D, Estrada Torres A. 2011. Biodiversity of myxomycetes from the Monte Desert of Argentina. Anales del Jardín Botánico de Madrid 68: 61–95. http://dx.doi.org/10.3989/ajbm.2266

Lado C, Wrigley de Basanta D, Estrada-Torres A, García-Carvajal E. 2014. Myxomycete diversity of the Patagonian Steppe and bordering areas in Argentina. Anales del Jardín Botánico de Madrid 71(1): e006. http://dx.doi.org/10.3989/ajbm.2394

Mitchell DW, Moreno G. 2013. A species of *Perichaena* new to North America. Boletín Sociedad Micológica de Madrid 37: 73–76.

Mitchell DW, Nannenga-Bremekamp NE, Champion CL, Clark MC. 1984. *Myxomycota* ramassés en France et conserves dans nos collections privées. Documents Mycologiques 14(54–55): 51–60.

Mitchell DW, Moreno G, Lizárraga M. 2011. A new species of coprophilous *Perichaena* from New Mexico. Boletín de la Sociedad Micológica de Madrid 35: 103–108.

Moreno G, Lizárraga M, Illana C. 2007. Catálogo de los myxomycetes de México. Boletín Sociedad Micológica de Madrid 31: 187–229.

Moreno G, Mitchell DW, Novozhilov YK. 2011. A new species of *Badhamia* (myxomycetes) confused with other species with similar morphology. Boletín de la Sociedad Micológica de Madrid 35: 95–102.

Nannenga-Bremekamp NE, Yamamoto Y. 1987. Additions to the myxomycetes of Japan III. Proceedings Koninklijke Nederlandse Akademie van Wetenschappen. Series C, Biological and Medical Sciences 90: 311–349.

Ndiritu GG, Winsett KE, Spiegel FW, Stephenson SL. 2009. A checklist of African myxomycetes. http://www.mycotaxon.com/resources/checklists/ndiritu_v107-checklist.pdf [Summary in Mycotaxon 107: 353–356. http://dx.doi.org/10.5248/107.353]

Novozhilov YK, Zemlyanskaya IV, Schnittler M, Stephenson SL. 2008. Two new species of *Perichaena* (myxomycetes) from arid areas of Russia and Kazakhstan. Mycologia 100: 816–822. http://dx.doi.org/10.3852/08-047

Pando F. 1989. Un estudio sobre los myxomycetes corticícolas de la isla de Mallorca. Anales del Jardín Botánico de Madrid 46(1): 181–188.

Stephenson SL, Nannenga-Bremekamp NE. 1990. Five new species of myxomycetes from North America. Proceedings Koninklijke Nederlandse Akademie van Wetenschappen. Series C, Biological and Medical Sciences 93: 187–195.

Wrigley de Basanta D, Lado C, Estrada-Torres A. 2010. *Licea eremophila*, a new myxomycete from arid areas of South America. Mycologia 102: 1185–1192. http://dx.doi.org/10.3852/09-309.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 521–526

http://dx.doi.org/10.5248/131.521

Marthamyces coronadoae sp. nov. in a *Fagus grandifolia* subsp. *mexicana* forest from Hidalgo State, México

Tania Raymundo[1], Ricardo Valenzuela[1]* & Martín Esqueda[2]

[1]*Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Plan de Ayala y Carpio s/n Col. Santo Tomas, México, D.F. 11340, México*

[2]*Centro de Investigación en Alimentación y Desarrollo, A.C. Apartado Postal 1735, Hermosillo, Sonora 83000, México*

* Correspondence to: *rvalenzg@ipn.mx*

Abstract—*Marthamyces coronadoae* is described as a new species from a relict forest of *Fagus grandifolia* subsp. *mexicana* in México. The specimens were collected on fallen and dead *Fagus* leaves in La Mojonera (in Zacualtipán municipality, Hidalgo State, México). This species is characterized by an apothecium opening by 4–5 pruinose and brownish beige teeth, a pale grey to pale yellow hymenial surface, and ascospores that are curved or coiled when released. A key to species of *Marthamyces* that grow in America is presented.

Key words—*Leotiomycetes, Marthamycetaceae,* propoloid fungi, taxonomy

Introduction

Minter (2003) established *Marthamyces* (with *M. emarginatus* (Cooke & Massee) Minter as type species) to accommodate taxa with filiform ascospores placed in *Propolis* sensu Sherwood (1977). The genus includes species that grow on abaxial and adaxial surfaces of fallen and dead plant leaves throughout the world, mainly in tropical and subtropical regions (Johnston 2006). *Marthamyces* is characterized by its apothecial ascomata that are subepidermal, orbicular to polygonal, resembling small pustules, erumpent from the substrate surface, not associated with bleaching of the surrounding substrate, and lacking zone lines (Minter 2003, Johnston 2006). The genus is characterized macroscopically by apothecia that are deeply immersed within the host tissue and a hymenial surface that often appears pruinose due to the presence of small crystals

amongst the paraphyses (Johnston 2006). Microscopically, the ascospores are filiform, 0–3-septate, and with apical and basal gelatinous caps, and the paraphyses have short branches near apex, tapering or swelling, tangled or with several short, finger-like projections, either often intermixed with crystals, or coated with crystals and with the tips of the paraphyses sometimes embedded in brownish gel (Sherwood 1977, Johnston 2006). The genus was formerly placed in *Rhytismataceae*, *Rhytismatales*, but recent phylogenetic studies in *Leotiomycetes* placed *Marthamyces* and *Propolis* in a clade separate from the *Rhytismatales* (Hustad & Miller 2011, Lantz et al. 2011). In 2015, Baral et al. established a new family *Marthamycetaceae* to accommodate the propoloid fungi (Baral 2015) and included *Cyclaneusma*, *Marthamyces, Mellitiosporiella*, *Mellitiosporium*, *Naemacyclus*, *Phragmiticola*, *Propolina*, and *Propolis*.

In México, only *Marthamyces quadrifidus* (Lév.) Minter has been recorded (specimen CU-ME-317, as *Propolis quadrifida*, from Oaxaca state; Sherwood 1977). In 2012, on a field survey of the relict forest of *Fagus grandifolia* subsp. *mexicana* (Martínez) A.E. Murray in La Mojonera (municipality Zacualtipán, Hidalgo State), México, several fallen leaves were collected that bore apothecia of the fungus here described as a new species of *Marthamyces*.

Materials & methods

The La Mojonera relict forest of *Fagus grandifolia* subsp. *mexicana* (*Fagaceae*) covers 45 ha at 2597 m asl. Its "montane cloud forest" vegetation comprises three arborous strata: higher (20–40 m), medium (8–20 m), and lower (2–8 m), and the higher stratum is dominated by *Fagus*, associated with *Magnolia schiedeana*, *Clethra macrophylla*, several *Quercus* species, *Pinus greggii*, and *P. patula* (Alcántara & Luna-Vega 2001, Williams-Linera et al. 2003, Godínez-Ibarra et al. 2007). Our specimens are deposited in the Herbarium, Instituto Politécnico Nacional, Mexico City, México (ENCB). Longitude and latitude coordinates were obtained with GPS eTrex (Garmin). Colors are coded according to Kornerup & Wanscher (1978). Morphological examinations were conducted as outlined by Sherwood (1977) and Johnston (2006). Measurements of anatomical characters were taken from rehydrated tissues in 5% aqueous KOH and Melzer's reagent. The macro-photos were taken with a Nikon D7000 and the micrographs with a Sony DSC-WX350. The meanings of some terms are based on Ulloa & Hanlin (2012) dictionary.

Taxonomy

Marthamyces coronadoae Raymundo, R. Valenz. & Esqueda, **sp. nov.** Figs 1–19

MycoBank MB 815275

Differs from *Marthamyces quadrifidus* by its dark apothecial teeth, curved to coiled ascospores when released, and paraphyses with several short, finger-like projections.

Type: México, Hidalgo, municipality of Zacualtipán, Ejido "La Mojonera", 28°06′56″N 111°01′35″W, alt. 2550 m, 17 July 2012, T. Raymundo 4324 (**Holotype**, ENCB).

Figs 1–6: *Marthamyces coronadoae* (holotype, ENCB Raymundo 4324). 1 Abaxial side of leaf. 2. Pustules erumpent on surface of leaf. 3, 5. Apothecia opening in teeth. 4, 6. Adaxial side of leaf. Scale bars: 1 = 10 mm; 2, 4 = 3 mm; 3 = 500 μm; 5 = 1 mm. 6 = 5 mm.

Etymology: In honor of Sonoran researcher Ecol. Martha Coronado, a pioneer in fungal ecology in Sonora State.

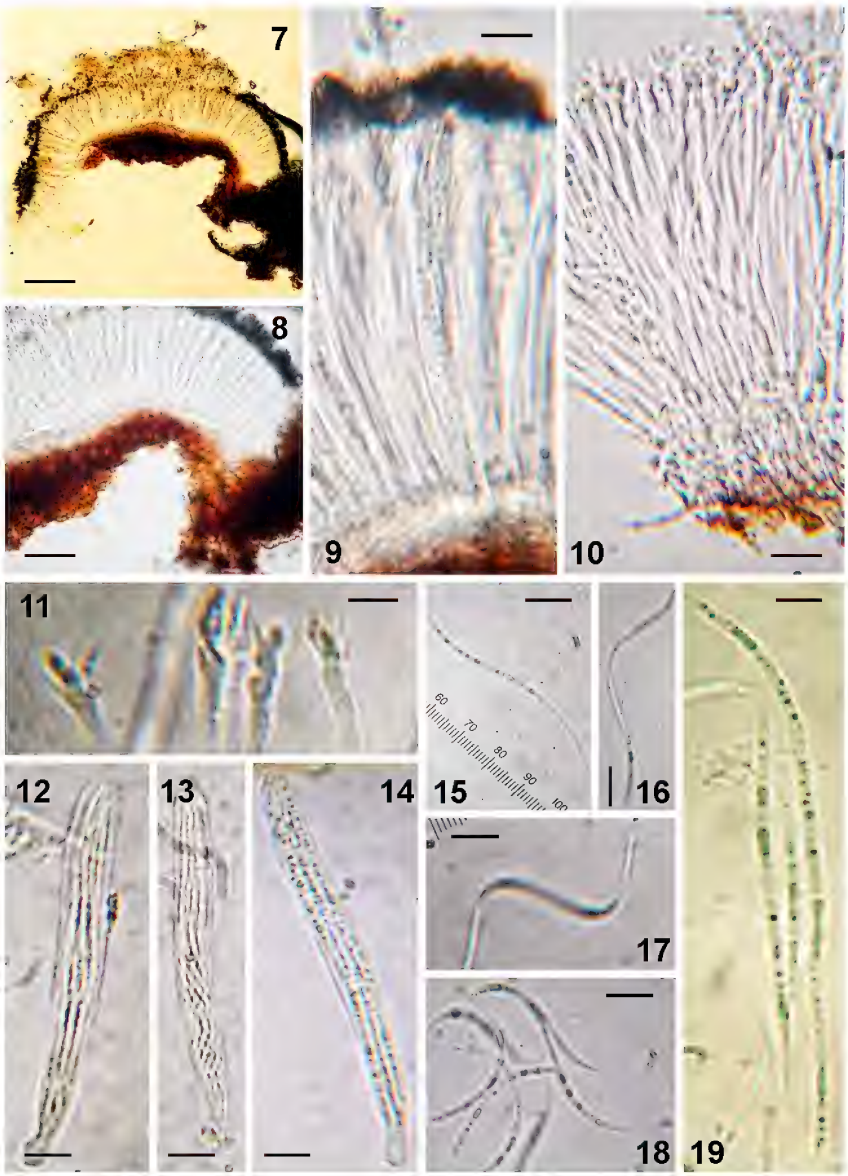
Apothecia 0.4–0.8 mm diam., on abaxial and adaxial surfaces of dead coriaceous leaves, subepidermal, resembling small pustules, visible initially as round black patches on leaf surface that raise as ascomata mature, erumpent from substrate surface, not associated with bleaching of host tissue, without zone lines, orbicular to polygonal, some rhomboid to pentagonal, others irregular in shape, superficial layer black in young apothecia, covering the hymenium, opening by 4–5 prominent, irregular, pruinose and brownish beige (6E3) teeth. Hymenium somewhat depressed below substrate level, pruinose, pale grey (1B1) to pale yellow (3A3) or pastel yellow (3A4) when fresh. Perimeter line absent. Subhymenium 10–15 µm thick, comprising small angular to globose cells, 1–2 µm diam., with hyaline walls. Paraphyses ≤100 µm long and 2 µm diam. (swelling slightly near apex ≤3 µm diam.) with several short, finger-like projections, at the apex coated with KOH-soluble crystals. Asci 70–90 × 6–8 µm, cylindric, with a foot-like base and a poorly developed basal stalk, tapering slightly at rounded apex, wall undifferentiated at apex, 8-spored. Ascospores slightly interwoven to irregularly arranged, or subparallel in the ascus, 60–74 (–80) × 1.6–2.4 µm, filiform, curved to coiled on release, hyaline in KOH, thin-walled, 0–1-septate, apical and basal gelatinous caps globose, 2.5–3 µm diam., gelatinous caps soluble in KOH.

Ecology & distribution—Found growing on fallen and dead leaves of *Fagus grandifolia* subsp. *mexicana* in montane cloud forest; known only from the type locality.

Comments—*Marthamyces coronadoae* is characterized by its orbicular to polygonal apothecia, the young apothecia erumpent through from a black covering layer, opening by 4–5 prominent, irregular and brownish beige teeth, its ascospores curved to coiled on release, 0–1-septate. *Marthamyces quadrifidus* is a similar species to *M. coronadoae*, but has 1–3-septate ascospores, more or less straight on release (Sherwood 1977, Cabarroi-Hernández et al. 2014) and it grows on several tropical and subtropical hosts (*Clusia*, *Eucalyptus*, *Lepidosperma*, *Mangifera*, *Myrtus*, *Rapanea*, etc.). *Marthamyces quercifolius* (Cooke & Ellis) Minter on *Quercus* and *Marthamyces phacidioides* (Fr.) Minter on *Ericaceae* and *Myricaceae* are also similar to *M. coronadoae*, but they differ by their 3-septate ascospores and their host preferences (Sherwood 1977).

Key to the species of *Marthamyces* in America

1. Ascospores 0–1-septate, apothecial teeth dark 2
1. Ascospores 3-septate, apothecial teeth pale 3



Figs 7–19: *Marthamyces coronadoae* (holotype, ENCB Raymundo 4324). 7, 8. Apothecium in transversal cut. 9. Crystals cover hymenial surface. 10. Paraphyses and asci on hymenial surface. 11. Apex of paraphyses with several short, finger-like projections. 12–14. Asci. 15–19. Ascospores. Scale bars: 7, 8 = 100 µm; 9, 10 = 10 µm; 11, 19 = 3 µm; 12, 15–18 = 5 µm. 13–14 = 8 µm.

2. On *Eucalyptus*, apothecia opening by 3–5 pruinose and black teeth,
hymenial surface pale grey,
ascospores straight or slightly curved on release ..... ***M. emarginatus***
2. On *Fagus*, apothecia opening by 4–5 pruinose and brownish beige teeth,
hymenial surface pale grey to pale yellow,
ascospores curved to coiled on release ..... ***M. coronadoae***
3. Tropical species, on *Clusia*, *Conocarpus*, *Mangifera*, *Myrtus*, *Rapanea*,
and many other hosts; hymenial surface pale grey ..... ***M. quadrifidus***
3. Temperate species, on *Quercus*, *Ericaceae*, and *Myricaceae;*
hymenial surface yellow 4
4. On *Quercus*, apothecia amphigenous;
ascospores 50–65 × 1.5 µm, straight on release ..... ***M. quercifolius***
4. On *Ericaceae* and *Myricaceae*, apothecia hypophyllous;
ascospores 60–75 × 1.5–2 µm, straight on release ..... ***M. phacidioides***

Acknowledgments

We wish to express our gratitude to Dr. Peter R. Johnston and Dr. José G. Marmolejo for reviewing the manuscript and their useful comments. We also express our gratitude to SEMARNAT—CONACYT (Grant 2002-C01-0409) for their financial support. Aldo Gutiérrez (CIAD) kindly prepared the manuscript and plates. R. Valenzuela and T. Raymundo thank COFAA and IPN for the financial support for their research in the project SIP-20150540, SIP-20151530, SIP-20161164, and SIP-20161166.

Literature cited

Alcántara O, Luna-Vega I. 2001. Análisis florístico de dos áreas con Bosque Mesófilo de Montaña en el Estado de Hidalgo, México: Eloxotlán y Tlahuelompa. Acta Botánica Mexicana 54: 51–87.

Baral HO. 2015. Nomenclatural novelties : H.O. Baral. Index Fungorum 225: 1–3.

Cabarroi-Hernández M, Johnston PR, Minter DW. 2014. *Rhytismataceae* (*Ascomycota*) in Cuba. Willdenowia 44: 65–75. http://dx.doi.org/10.3372/wi.44.44110

Godínez-Ibarra O, Pérez Á, López-Mata G, García-Moya L, Valdez-Hernández E, de los Santos-Posadas JI, Trinidad-Santos A. 2007. Lluvia de semillas y emergencia de plántulas de *Fagus grandifolia* subsp. *mexicana* en La Mojonera, Hidalgo, México. Revista Mexicana de Biodiversidad 78: 117–128.

Hustad VP, Miller AM. 2011. Phylogenetic placement of four genera within the *Leotiomycetes* (*Ascomycota*). North American Fungi 6(9): 1–13. http://dx.doi.org/10.2509/naf2011.006.009

Johnston PR. 2006. *Rhytismatales* of Australia: the genus *Marthamyces*. Australian Systematic Botany 19: 135–146. http://dx.doi.org/10.1071/SB05010

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. 3th ed. Eyre Methuen, London.

Lantz H, Johnston PR, Park D, Minter DW. 2011. Molecular phylogeny reveals a core clade of *Rhytismatales*. Mycologia 103: 57–74. http://dx.doi.org/10.3852/10-060

Minter DW. 2003. *Propolis* and *Marthamyces* gen. nov. (*Rhytismatales*). Mycotaxon 87: 43–52.

Sherwood MA. 1977: Taxonomic studies in the *Phacidiales*: *Propolis* and *Propomyces*. Mycotaxon 5: 320–330.

Ulloa M, Hanlin RT. 2012. Illustrated dictionary of mycology. 2nd ed. APS Press, St. Paul, Minnesota, USA.

Williams-Linera G, Rowden A, Newton AC. 2003. Distribution and stand characteristics of relict population of Mexican beech (*Fagus grandifolia* var. *mexicana*). Biological Conservation 109(1): 27–36. http://dx.doi.org/10.1016/S0006-3207(02)00129-5

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 527–533

http://dx.doi.org/10.5248/131527

Lithothelium bermudense sp. nov., a new saxicolous lichen from Bermuda

Franz Berger[1*], Scott LaGreca[2] & André Aptroot[3]

[1] *Raiffeisenweg 130, A–4794, Kopfing, Austria*

[2] *Plant Pathology Herbarium, School of Integrative Plant Science, 334 Plant Science Building, Cornell University, Ithaca, New York 14853-5904 USA*

[3] *ABL Herbarium, G.v.d.Veenstr. 107, NL-3762 XK Soest, The Netherlands*

[*] Correspondence to: *flechten.berger@aon.at*

Abstract—*Lithothelium bermudense* is described as a new saxicolous lichen from Bermuda, characterized mainly by its endolithic thallus and red-brown 3-distoseptate spores with diamond-shaped lumina.

Key words—endemic, *Pyrenulaceae*, taxonomy, Walsingham

Introduction

The genus *Lithothelium* Müll. Arg. comprises at least 33 species of pyrenocarpous lichens in the *Pyrenulaceae* (Aptroot 2006, 2007, McCarthy 2015, Gueidan et al. 2016). It is characterized by distoseptate ascospores with rounded lumina, unbranched paraphyses (reported to be anastomosing in one species) and cylindrical asci that have a conspicuous ocular chamber. The ocular chamber is often rounded, but in some species (or specimens) it is decidedly invaginated (sagittiform). It cannot, however, be ruled out that this invagination is simply a more mature developmental stage, as it seems to be more common in asci with mature spores, just prior to ascospore release. Most species occur in the tropics; only a few are widely distributed or locally abundant. As the name already suggests (the prefix "Litho-" derived from the Greek word *lithos*, meaning "stone"), some species occur on rock, a characteristic otherwise unknown in this family.

As part of an ongoing revision of Bermudian lichens by the first two authors (Berger & LaGreca 2014), a lichen was collected in 2007 that was recognized by

the third author as a new species of *Lithothelium*. The islands that make up the Bermuda archipelago—basically fossilized dunes (Vacher & Rowe 1997)—are roughly 900,000 years old and among the most isolated islands in the world, leading to the evolution of a number of endemic organisms (Thomas 2004). The new *Lithothelium* species described here was collected in the Walsingham Nature Reserve (Hamilton Parish), one of Bermuda's last remaining primary-growth forests. It is one of the last places on Bermuda where one can find large specimens of the endemic Bermudian trees, *Cassine laneana* (Bermuda olivewood) and *Sabal bermudana* (Bermuda sabal), which were (together with *Juniperus bermudiana*, the Bermuda cedar) at one time the dominant trees in this wet evergreen jungle. The area has escaped the strong developmental pressures that have altered so much of the archipelago by virtue of its rough terrain of hard limestone, which has broken through the soil surface in many places due to the partial collapse of the ceilings of caves below. As this area also lies in the lee of the prevailing westerly winds, it is somewhat protected from storms, which contributes to its status as the most undisturbed, pristine forest on Bermuda. Walsingham is home to Bermuda's most diverse and important cryptogam communities (Britton 1918, Rendle 1936), including some endemic species of ferns and lichens. Indeed, the new species described below appears to be endemic to Bermuda and grows in close association with other characteristic Bermudian lichens, as elaborated below.

Materials & methods

This paper is based on specimens collected in 2007 by the first two authors, deposited in the Herbarium, Department of Botany, The Natural History Museum, London, U.K. (BM), the Herbarium, Adviesbureau voor Bryologie en Lichenologie, Soest, the Netherlands (ABL), and the private herbarium of F. Berger (hb Berger). The specimens were examined with an Olympus SZX7 stereomicroscope and an Olympus BX50 compound microscope with interference contract, connected to a Nikon Coolpix digital camera. Microscope sections were cut by hand and mounted in water. Spores were also examined in 10% KOH.

Taxonomy

Lithothelium bermudense F. Berger, LaGreca & Aptroot, **sp. nov.** FIGURES 1–3

MycoBank MB 815588

Differs from *Lithothelium australe* by its clavate asci and its diamond-shaped spore lumen; from *L. austropacificum* by its calcareous substrate, its lack of a visible thallus, and its euseptate ascospores; and from *L. echinatum* by possessing larger spores that lack spiky ornamentation.

TYPE: Bermuda, Hamilton Parish, Walsingham Nature Reserve, Tom Moore Trail, 32°20.7′N 64°42.75′W, alt. 3 m, on hard limestone, 2 November 2007, F. Berger 22300 & S. LaGreca (**Holotype**, BM000921379; **isotypes**, ABL, hb Berger).

Fig. 1. *Lithothelium bermudense* (holotype, BM000921379).
Scale bar = 0.5 mm.

Etymology: named for the Bermuda Isles, the UK Overseas Territory where the first specimens were collected.

Description — Thallus endolithic, appearing as a pink to pale brownish spot on calcareous rock, up to 2 cm diam., prothallus absent; algae *Trentepohlia*, cells c. 8 µm diam. Ascomata solitary, black, closed, conical, ½–⅔-immersed, leaving black pits, smooth, 0.4–0.6 mm diam; walls brittle like charcoal; excipulum and involucrellum fully integrated, the latter throughout carbonized, combined wall c. 150–200 µm thick above and at the sides, c. 100 µm thick below the asci, KOH–. Ostiolum central, apical, inconspicuous, hymenium not inspersed with oil globules, gel IKI–. Paraphyses unbranched, slender, c. 1–1.5 µm wide, no periphyses. *Asci* subcylindrical to clavate, 110 × 25–30 µm, fissitunicate, with a rounded ocular chamber (at least when the ascospores are mature), wall to 5 µm thick, containing 6–8 ascospores. Ascospores biseriate, fusiform with protruding brighter tips, reddish-brown, darkening in KOH, initially with 1 euseptum, later with 2 additional, incomplete eusepta and always with 3 distosepta, endospore c. 2 µm thick, terminal lumina distinctly smaller, and protruding into the apical exospore, inner lumina diamond-shaped, 20–25 × 7–8 µm, with an open tubulus between the outer and inner

Fig. 2. *Lithothelium bermudense* (holotype, BM000921379).
A. Clavate ascus with young ascospores. B. Ascus with mature ascospores. Scale bars = 10 µm.

lumina which is present until maturity, gelatine coat (perispore) absent, spore wall not ornamented, spores becoming dark brown and finally shrinking (when over-mature). Pycnidia not observed.

Ecology & Distribution — Grows together with *Ionaspis tropica* Riddle, *Stromatella bermudana* (Riddle) Henssen, and small liverworts on low, sheltered, limestone outcrops in primary coastal forest. Associated species include *Strigula bermudana* (Tuck. ex Nyl.) R.C. Harris, *Gyalecta farlowii* Tuck., *Toninia* sp.,

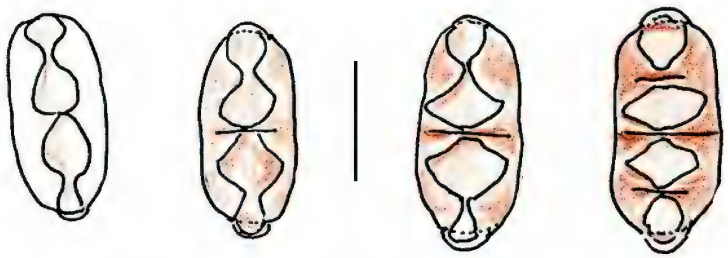


Fig. 3. *Lithothelium bermudense* (isotype, hb Berger).
Ascospores, showing increasing maturity from left to right. Scale bar = 10 µm.

Opegrapha sp., *Cryptothecia striata* G. Thor, *Lempholemma lingulatum* (Tuck.) Henssen, *Collema thamnodes* Tuck. ex Riddle, *Leptogium austroamericanum* (Malme) C.W. Dodge, and *Paulia* sp. Known from one specimen from the Walsingham Nature Reserve, Bermuda.

Notes — This new species superficially resembles endolithic *Verrucaria* spp., but is easily distinguished by the red-brown, 3-distoseptate spores. According to Aptroot (2006), it would key out as *Lithothelium australe* Aptroot & H. Mayrhofer from Chatham Island, New Zealand, but the new species differs from *L. australe* by possessing a different type of spore lumen, as well as clavate asci. *Lithothelium bermudense* is most similar to another *Lithothelium* species with brown ascospores with diamond-shaped lumina, *L. austropacificum* P.M. McCarthy, from Lord Howe Island, Australia. However, *L. austropacificum* lacks eusepta, occurs on basalt, and possesses a conspicuous thallus (McCarthy 1996). One more diagnostic feature of *L. bermudense* is the protruding terminal lumen, the result of a spore ontogeny that is unique among saxicolous *Lithothelium* species. Young spores always have three distosepta perforated at each side by a tubulus between the inner and terminal lumina; at maturity, by comparison, one euseptum is always present in the middle of the spores, but never touches the external walls (Figs 2B, 3). Overmature spores inevitably lose the tubulus, and two more discrete eusepta between the lumina are developed. In addition, the spore colour darkens with ongoing maturity.

There is another endolithic lichen more often encountered on calcareous substrates in Bermuda, *Strigula bermudana* (Berger & LaGreca 2014), which is very similar in appearance to *L. bermudense*. Microscopical investigation, however easily reveals the differences: the spores of *S. bermudana* are always hyaline, euseptate, and incised at the septum, 14–16 × 4–5.9 µm; i.e., the spores are much smaller, and narrower in shape, compared with *L. bermudense*.

Discussion

Lithothelium species differ mainly in ascospore size and pigmentation (from hyaline to red brown), relative sizes and forms of the lumina, corticolous vs. saxicolous habit, immersed vs. superficial thallus, and apical vs. lateral ostiole position. The ascomata can be solitary or clustered in groups and with or without a common ostiole. Species with brown ascospores resemble members of the genus *Pyrenula* Ach., which differ by having brown to grey ascospore pigmentation (not red brown) and lumina that are angular (not rounded) when the ascospores are mature. The fact that mature *Lithothelium* ascospores resemble immature ascospores of some *Pyrenula* species suggests that neoteny is an evolutionary theme in the *Pyrenulaceae* (Aptroot 2006). In its current circumscription, *Lithothelium* is polyphyletic (Gueidan et al. 2016).

According to previous studies of *Lithothelium* (Aptroot 2006, 2007), as well as the worldwide key provided by Aptroot (2006: 544), only two previously described species possess the combination of coloured ascospores, an endolithic thallus, and occurrence on calcareous rocks. The more similar to *L. bermudense* is the Australasian *L. australe* (Aptroot & H. Mayrhofer 1991); while the dimensions of all anatomical features of these two species overlap, the difference in spore ontogeny (as reported above) is clear. The other similar endolithic species found on calcareous rock, *L. echinatum* Aptroot, occurs in China; it differs in having smaller spores with a spiky ornamentation.

Most species of *Lithothelium* are uncommon, and relatively inconspicuous. They often possess immersed, whitish thalli and so are frequently mistaken for non-lichenized fungi in the field. Because of this, they are undercollected by lichenologists, except in some parts of North America and tropical Asia, where some species are locally abundant. Because of the scattered collections of so many species, and the fact that most species are still known only from one country (or even one specimen), it is impossible to estimate the level of endemism in various geographic regions, or the centre(s) of diversity of the whole genus. As limestone outcrops are relatively scarce in the tropics, however, tropical species such as *L. bermudense*—assuming it only occurs on calcareous rock—may indeed have a very restricted geographic distribution.

Acknowledgments

This work was supported by a grant to FB and SLG from the Bermuda Zoological Society. Christine Watlington is warmly thanked for generously providing accommodation for SLG, and for assisting with all aspects of our fieldwork. Jack Ward graciously provided access to, and fieldwork assistance in, Walsingham Nature Reserve. Adam Flakus (KRAM) and Roger Rosentreter (SRP) provided helpful reviews of the manuscript prior to publication. Erich Zimmermann is kindly thanked for providing

the photos. This is contribution number 143 of the Bermuda Biodiversity Project (BBP), Bermuda Aquarium, Natural History Museum and Zoo.

Literature cited

Aptroot A. 2006. Three new species of *Lithothelium* (*Pyrenulaceae*) from China and Thailand, with a revised world key and annotated list of species. Lichenologist 38: 541–548.

Aptroot A. 2007. New species, combinations, lectotypifications and synonyms on Australian *Pyrenulaceae*. Australasian Lichenology 60: 34–41.

Aptroot A, Mayrhofer H. 1991. *Lithothelium australe* spec. nov., a new lichen from New Zealand. Mycotaxon 41: 219–222.

Berger F, LaGreca S. 2014. Contributions to the lichen flora of Bermuda—part I. New records, new combinations, and interesting collections of lichenized ascomycetes. Evansia 31: 41–68. http://dx.doi.org/10.1639/079.031.0203

Britton NL. 1918. The flora of Bermuda. New York: Scribner's.

Gueidan C, Aptroot A, Cáceres ME, Nguyen QB. 2016. Molecular phylogeny of the tropical lichen family *Pyrenulaceae*: contribution from dried herbarium specimens and FTA card samples. Mycological Progress 15: 7. http://dx.doi.org/10.1007/s11557-015-1154-8

Rendle AB. 1936. Notes on the flora of the Bermudas. Journal of Botany 74: 42–50.

McCarthy PM. 1996. *Lithothelium austropacificum* sp. nov. (*Pyrenulaceae*) from Lord Howe Island, Australia. Lichenologist 28: 290–294.

McCarthy PM. 2015. A new species of *Lithothelium* (lichenized Ascomycota, *Pyrenulaceae*) from the Tarkine region, north-western Tasmania. Telopea 18: 167–170. http://dx.doi.org/10.7751/telopea8890

Thomas MLH. 2004. The natural history of Bermuda. Bermuda Aquarium, Natural History Museum & Zoo, and Bermuda Zoological Society.

Vacher HL, Rowe MP. 1997. Geology and hydrology of Bermuda. Developments in Sedimentology 54: 35–90. http://dx.doi.org/10.1016/S0070-4571(04)80022-0

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 535–539

http://dx.doi.org/10.5248/131.535

Harmoniella campanaensis sp. nov. from central Chile

Hugo Madrid[1,2*], Daniela Torres[1] & Víctor Silva[2]

[1] *Center for Genomics and Bioinformatics, Mayor University &*

[2] *Science Faculty, Mayor University,*
Camino La Pirámide 5750, Huechuraba, Santiago, Chile

* Correspondence to: *hugo.madrid@umayor.cl*

Abstract—A new hyphomycete, *Harmoniella campanaensis*, is described from submerged dicotyledonous leaves collected in La Campana National Park, central Chile. This fungus is the second taxon described in *Harmoniella* and the only one known from the Americas. *Harmoniella campanaensis* differs from the generic type, *H. chrysocephala*, by producing much longer conidiophores (with stipes up to 850 µm) and shorter conidia (3–5 µm long).

Key words—conidial fungi, sympodial development, taxonomy

Introduction

During June 2015, fieldwork was carried out in central Chile with the aim to collect saprophytic microfungi from soil and plant material. One of the sampled sites was La Campana National Park (Valparaíso Region), a vast protected area with a Mediterranean climate and a rich endemic flora consisting of a hygrophilous laurifolious forest dominated by species such as *Aristotelia chilensis* (Molina) Stuntz, *Beilschmiedia miersii* (Gay) Kosterm., and *Cryptocarya alba* (Molina) Looser (Elórtegui & Moreira-Muñoz 2002). Although we were mainly interested in graminicolous helminthosporioid genera (Madrid et al. 2014, Manamgoda et al. 2014), many other interesting hyphomycetes were also found, including new species and new records.

One interesting fungus was obtained from submerged dicotyledonous leaves. Under the stereomicroscope, it showed conspicuous erect conidiophores with a vesicle at the apex and produced masses of dry ochraceous conidia resembling an *Aspergillus* species. However, the fungus produced conidiophores with

strongly pigmented stipes and a tendency to proliferate percurrently through old vesicles. A more detailed observation with light microscopy showed that it produced septate conidiophores and sympodial, strongly denticulate conidiogenous cells. Morphological features place this taxon in the monotypic genus *Harmoniella* V.N. Boriss. (Borisova 1981, Seifert et al. 2011). However, the dimensions of conidiophores and conidia and the substrate from which it was isolated clearly indicate that it is different from the generic type, *H. chrysocephala* V.N. Boriss.

Materials & methods

Submerged decaying leaves, twigs, and wood were collected in a stream in La Campana National Park, Valparaíso Region, Central Chile. Samples were placed in sterilized polyethylene bags, transported to the laboratory and kept at 4°C until processed. The samples were placed in moist chambers, incubated at room temperature and observed weekly for two months. Isolation of the studied *Harmoniella* species was attempted by transferring conidia from conidiophores on the natural substrate to Petri dishes containing either cornmeal agar, oatmeal agar, Sabouraud agar (all manufactured by Becton Dickinson, USA), or water agar; the water agar plates were prepared with or without sterilized pine needles or maize leaves. The morphological study was carried out from lactophenol mounts using a Zeiss AxioScope A1 light microscope. A specimen was deposited in the Herbarium of the National Natural History Museum, Santiago, Chile (SGO).

Taxonomy

Harmoniella campanaensis Madrid, D. Torres & V. Silva, **sp. nov.** Plate 1

MycoBank MB 815759

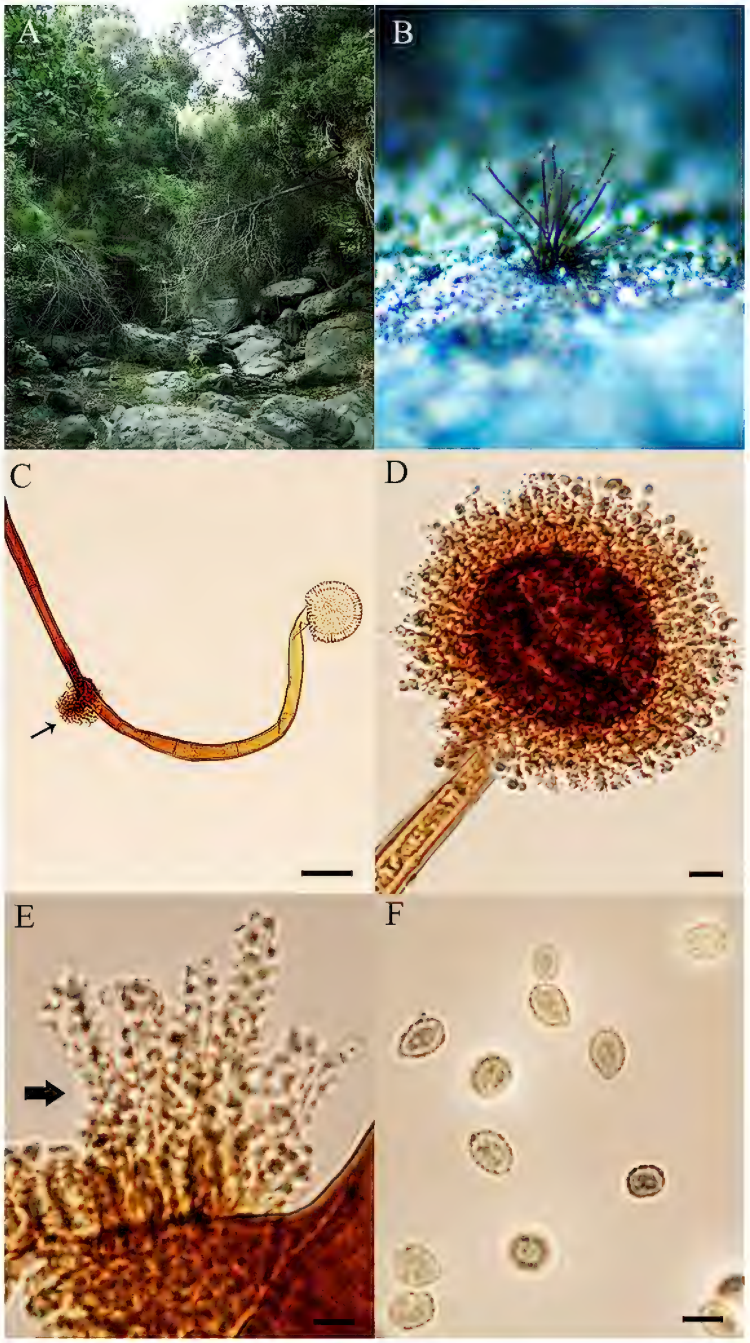
Differs from *Harmoniella chrysocephala* by its much longer conidiophores, which often proliferate percurrently, and by its shorter conidia.

Type: Chile, Marga Marga Province, La Campana National Park, El Granizo area, on submerged decaying dicotyledonous leaves, 30 Jun 2015, H. Madrid (**Holotype**, SGO 166366, dried leaf).

Etymology: *campanaensis* refers to the place where the fungus was collected, La Campana National Park.

Vegetative hyphae septate, branched, light olivaceous brown, smooth, up 4 µm wide. Conidiophores macronematous, mononematous, solitary to caespitose, often proliferating percurrently, straight to slightly flexuous, septate, light olivaceous brown to dark reddish brown, thick-walled, with a

Plate 1. *Harmoniella campanaensis* (holotype, SGO 166366). A. Sampling area in La Campana National Park; B. Conidiophores on the natural substrate; C. Conidiophore showing percurrent proliferation (arrow); D. Vesicle and conidiogenous cells; E. Sympodial conidiogenous cells with denticles (arrow); F. Conidia. Scale bars: C = 50 µm; D = 10 µm; E, F = 5 µm.


A
B
C
D
E
F

subcylindrical stipe and a well-developed vesicle at the apex; stipe 688–850 × 11.5–22 µm, sometimes broadened up to 35 µm toward the base; vesicle globose to depressed-globose, light olivaceous brown when young, dark brown at maturity, 44–59.5 µm wide. Conidiogenous cells covering the vesicle radially, forming a compact single layer, subcylindrical, 12–18.5 × 3–4 µm, with numerous denticles up to 2 µm long. Conidia dry, aseptate, ellipsoid to dacryoid, verruculose to echinulate, light olivaceous to light olivaceous brown, ochraceous in mass, 3–5 × 2.5–4 µm.

Comments: All attempts to obtain this fungus in culture were unsuccessful, despite the use of different media. Therefore, no DNA sequence analyses could be carried out and its phylogenetic placement remains unknown. Borisova (1981), in the description of the type species, also pointed out its inability to grow in vitro. *Harmoniella chrysocephala* was described from pine needles in Yalta, Ukraine, and we could not find any record of this species from a different country; the Global Biodiversity Information Facility (www.gbif.org) yields no records of *H. chrysocephala* outside the type locality. *Harmoniella chrysocephala* differs from *H. campanaensis* by its much smaller conidiophores (150–170 × 12–17 µm) and longer conidia (6–7.2 × 3.6–4.8 µm), which are more irregular in shape (Borisova 1981). In addition to these differences, the dissimilar habitats (pine needles versus submerged dicotyledonous leaves) and the tendency of the Chilean fungus to develop percurrently proliferating conidiophores prompted us to propose this organism as a taxonomic novelty.

Harmoniella has been listed, with some doubt, as a possible synonym of *Pseudogibellula* Samson & H.C. Evans (Seifert et al. 2011). *Pseudogibellula* is monotypic and based on *Gibellula formicarum* Mains [≡ *P. formicarum* (Mains) Samson & H.C. Evans], the asexual state of *Torrubiella pseudogibellulae* Samson et al., a member of *Clavicipitaceae* (Mains 1949, Samson & Evans 1973). We prefer to treat *Harmoniella* as a separate genus due to important ecological and morphological differences. *Pseudogibellula* is an entomopathogen that attacks insects and arachnids whereas *Harmoniella* species are associated with decaying plant material (Seifert et al. 2011). Furthermore, the structure of the conidial apparatuses is quite different; *Harmoniella* has mononematous smooth conidiophores with wide vesicles, which are covered directly by conidiogenous cells, while *Pseudogibellula* produces synnemata and verrucose conidiophores with very small vesicles (4–6 µm wide), covered by two series of metulae (Samson et al. 1988). Conidiogenous cells are also dissimilar, showing conspicuous denticles in *Harmoniella* but only minute scars in *Pseudogibellula* (Seifert et al. 2011).

Acknowledgments

We would like to thank Drs. David Minter (CABI, Wallingford, England) and Keith Seifert (Agriculture and Agri-Food Canada, Ottawa, Canada), and the Cyberliber website (http://www.cybertruffle.org.uk/cyberliber/) for providing information and literature about *Harmoniella* and related taxa. We would also like to thank Dr. José Luis Rodríguez (Clínica Las Condes, Santiago, Chile) for translating taxonomic literature in Russian to Spanish, and Drs. Josepa Gené and Josep Cano (Universitat Rovira i Virgili, Reus, Spain) for critically reviewing this work and providing helpful suggestions about it. Corporación Nacional Forestal (CONAF), Chile, is acknowledged for providing permission to collect biological samples in La Campana National Park. Hugo Madrid was funded by Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Fondo Nacional de Desarrollo Científico y Tecnológico (FONDECYT), Chile, project no. 11140562.

Literature cited

Borisova VN. 1981. *Harmoniella*, a new genus of hyphomycetes. Mikol. Fitopat. 15: 89–92.

Elórtegui S, Moreira-Muñoz A. 2002. La Campana National Park: origin of a Biosphere Reserve in central Chile. Taller La Era, Santiago.

Madrid H, da Cunha KC, Gené J, Dijksterhuis J, Cano J, Sutton DA, Guarro J, Crous PW. 2014. Novel *Curvularia* species from clinical specimens. Persoonia 33: 48–60. http://dx.doi.org/10.3767/003158514X683538

Mains EB. 1949. New species of *Torrubiella*, *Hirsutella* and *Gibellula*. Mycologia 41: 303–310. http://dx.doi.org/10.2307/3755112

Manamgoda DS, Rossman AY, Castlebury LA, Crous PW, Madrid H, Chukeatirote E, Hyde KD. 2014. The genus *Bipolaris*. Stud. Mycol. 79: 221–288. http://dx.doi.org/10.1016/j.simyco.2014.10.002

Samson RA, Evans HC. 1973. Notes on entomogenous fungi from Ghana. I. The genera *Gibellula* and *Pseudogibellula*. Acta Bot. Neerl. 22: 522–528. http://dx.doi.org/10.1111/j.1438-8677.1973.tb00873.x

Samson RA, van Reenen-Hoekstra ES, Evans HC. 1988. New species of *Torrubiella* (*Ascomycotina*: *Clavicipitales*) on insects from Ghana. Stud. Mycol. 31: 123–132.

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 541–545

http://dx.doi.org/10.5248/131.541

Rosellinia hainanensis sp. nov. and three *Rosellinia* species new to China

Wei Li & Lin Guo*

State Key Laboratory of Mycology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, China

* Correspondence to: *guol@im.ac.cn*

Abstract—A new species *Rosellinia hainanensis* is proposed, and three other species, *R. compacta, R. eucalypticola*, and *R. siggersii,* are described as new to China. The four species were collected from Hainan and Yunnan provinces.

Key words—*Ascomycota*, pyrenomycetous fungi, *Xylariaceae*, taxonomy

Introduction

Thirty-six species of *Rosellinia* have previously been reported from China, but 15 of them (including *R. mycophila*, *R. pulveracea*, and *R. sordaria*) have been transferred to other genera such as *Amphisphaerella* and *Coniochaeta*. Consequently, only 21 species currently accepted in *Rosellinia* have been recorded in China (Teng 1963; Tai 1979; Ju & Rogers 1990, 1999; Yuan & Zhao 1993; Lu et al. 2000; Liu et al. 2010; Petrini 2013a,b; Li & Guo 2015). Here we describe a new species collected in Hainan and report three other species new to China.

Materials & methods

The specimens were examined macroscopically with the aid of a Motic SMZ-168 dissecting microscope. Microscopic features of asci and ascospores were described from slide preparations mounted in water and Melzer's reagent, and measurements were made from 20 ascospores, using a Zeiss Axioskop 2 plus compound microscope. Photographs of stromata were taken using a Sony NEX-7. All specimens have been deposited in the Herbarium Mycologicum Academiae Sinicae, Beijing, China (HMAS).

Taxonomy

Rosellinia hainanensis Wei Li bis & L. Guo, **sp. nov.** Figs 1–3

Fungal Name FN 570257

Differs from *Rosellinia spiraliterfissurata* by its shorter and broader ascospores and from *R. chusqueae* by its higher ascus apical ring.

Type: China, Hainan, Changjiang, Bawangling, alt. 603 m, on little twigs of unidentified plant, 11.XII.2009, Y. F. Zhu & L. Guo 123 (**Holotype**, HMAS 269892).

Etymology: The epithet refers to the type locality.

Stromata solitary or crowed, pear shaped, surface coarse and black, 0.5–0.74 mm high, 0.5–0.9 mm wide. Ostioles irregular, indistinctly papillate, black. Subiculum black, reduced to stroma base, evanescent. Ectostroma 60–80 µm thick, black. Entostroma disappearing at maturity. Asci eight-spored, cylindrical, the spore bearing part 125–145 µm long, 12–15 µm broad, with apical ring 7–10 µm high, 3–5 µm broad and bluing in Melzer's iodine reagent,. Ascospores dark brown, surrounded by a slimy sheath, asymmetrically ellipsoidal, with broadly rounded ends, 21–24 × 11–13 µm, with sigmoid germ slit slightly shorter than spore-length.

Comments: *Rosellinia hainanensis* is similar to *Rosellinia spiraliterfissurata* L.E. Petrini, which differs by having longer and narrower ascospores (26.5–34 × 7–11 µm; Petrini 2013a,b). *Rosellinia chusqueae* Pat. differs from *Rosellinia hainanensis* by its shorter apical ring (6.7–7 µm high; Petrini 2013b).

Rosellinia hainanensis is described in *Rosellinia* (rather than *Helicogermslita*) because the holotype lacks the helical ascospore germ slit that is the most distinctive character of *Helicogermslita.*

Rosellinia compacta Takemoto, Mycologia 101: 89, 2009. Figs 4–5

Stromata crowed, subglobose, copper brown, black, 0.8–1.2 mm high, 0.9–1.2 mm wide. Ostioles papillate, black. Subiculum dark brown. Ectostroma 80–140 µm thick, black. Entostroma brown. Perithecia subglobose, 550–660 µm high, 700–920 µm wide. Asci eight-spored, cylindrical, 252–275 µm total length, 8–13 µm broad, the spore bearing part 220–229 µm long, with apical ring bluing in Melzer's iodine reagent, with rounded or angular bulge at upper rim, 9–12 µm high, 3.5–7 µm broad. Ascospores light brown or brown, surrounded by a slimy sheath, asymmetrically fusiform-shaped, with thread-

---

Figs 1–9. ***Rosellinia hainanensis*** (HMAS 269892, holotype). 1. Stromata on twig; 2. Ascus and ascospores; 3. Ascospore. ***Rosellinia compacta*** (HMAS 253036). 4. Stromata on wood; 5. Ascus and ascospores. ***Rosellinia eucalypticola*** (HMAS 245220). 6. Stromata on wood; 7. Ascus and ascospores. ***Rosellinia siggersii*** (HMAS 253035). 8. Stromata on wood; 9. Ascospore.

1
2
10 µm
3
10 µm
4
5
10 µm
6
7
10 µm
8
9
10 µm

like ends, 41–49(–55) × (5–) 6–9 µm, with a longitudinal straight germ slit spore-length in the center.

Specimens examined: China, Yunnan, Mengla, Menglun, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, alt. 570 m, on corticated wood, 16.X.2013, W. Li 2930 (HMAS 253039); W. Li 2949 (HMAS 253036).

Comments: *Rosellinia arcuata* Petch differs from *R. compacta* by larger stromata (0.9–2.75 mm high, 1.1–2.5 mm wide; Petrini 2013b); and *Rosellinia necatrix* Berl. ex Prill. differs from *R. compacta* by smaller ascospores (30.6–46.8 × 5.4–8.1 µm) and larger stromata (1–1.9 mm high, 1.2–2 mm wide; Petrini 2013b).

Rosellinia eucalypticola Henn. & E. Nyman, Monsunia 1: 166, 1899. Figs 6–7

Stromata solitary or 2–4 gregarious, globose or subglobose, surface smooth and black, 0.44–0.7 mm high, 0.66–1 mm wide. Ostioles papillate, black. Subiculum reduced to stroma base, evanescent. Ectostroma 40–80 µm thick, black. Entostroma brown. Perithecia subglobose, 400–500 µm high, 560–700 µm wide. Asci eight-spored, cylindrical, 100–120 µm total length, 6–7.5 µm broad, the spore bearing part 60–67 µm long, with apical ring bluing in Melzer's iodine reagent, 1.5–2 µm high, 1.5–3 µm broad. Ascospores light brown or brown, asymmetrically ellipsoidal, with broadly rounded ends, 8.5–11 × 4.5–5.5 µm, with straight germ slit as long as or slightly shorter than spore.

Specimens examined: China, Hainan, Changjiang, Bawangling, alt. 650 m, on decorticated wood, 10.I.2009, W. Li, X.Y. Liu 2216 (HMAS 245220).

Rosellinia siggersii L.E. Petrini, Index Fungorum 25: 4, 2013. Figs 8–9

Stromata crowded, subglobose, semiglobose to cupulate, sometimes with a broad, short stipe, dark brown, 1.4–1.8 mm high, 1.4–1.6(–2) mm wide. Ostioles papillate to conical, black. Subiculum woolly, dark red brown, with synnemata. Ectostroma 80–160 µm thick, black. Entostroma white or cream, disappeared at maturity. Perithecia subglobose, 900–1000 µm high, 1300–1500 µm wide. Asci eight-spored, cylindrical, 277–365 µm total length, 9–10 µm broad, the spore bearing part 200–252 µm long, with apical ring bluing in Melzer's iodine reagent, ampulliform, 12–12.5 µm high, 4–7 µm broad. Ascospores light brown or brown, asymmetrically fusiform-shaped, with thread-like ends, 41–46(–52) × 5–8 µm, with straight germ slit on flat side, 9–13 µm long, shorter than spore.

Specimens examined: China, Yunnan, Jinghong, Dadugang, alt. 1300 m, on corticated wood, 15.X.2013, W. Li 3104 (HMAS 253035).

Comments: *Rosellinia siggersii* differs from *R. acutispora* (Theiss.) L.E. Petrini by its ascospores with thread like, elongated and pinched ends (Petrini 2013a,b).

Discussion

China is a vast country with many different geographical zones, and it is probable that continuing field expeditions and study will reveal additional *Rosellinia* species.

Acknowledgments

The authors would like to express their deep thanks to Drs. L. Vasilyeva (Vladivostok, Russia) and L.E. Petrini (Breganzona, Switzerland) for serving as pre-submission reviewers, to Dr. Shaun Pennycook (Auckland, New Zealand) for nomenclatural review, to the support by the Ministry of Science and Technology of the People's Republic of China (No. 2013FY110400).

Literature cited

Ju YM, Rogers JD. 1990. *Astrocystis* reconsidered. Mycologia 82(3): 342–349. http://dx.doi.org/10.2307/3759905

Ju YM, Rogers JD. 1999. The *Xylariaceae* of Taiwan (excluding *Anthostomella*). Mycotaxon 73: 343–440.

Li W, Guo L. 2015. *Rosellinia brunneola* sp. nov. and *R. beccariana* new to China. Mycotaxon 130: 233–236. http://dx.doi.org/10.5248/130.233

Liu CF, Lu T, Gao JM, Wang MQ, Lu BS. 2010. Two new Chinese records of *Rosellinia*. Mycosystema 29(3): 459–462.

Lu BS, Hyde KD, Ho WH. et al. 2000. Checklist of Hong Kong Fungi. Fungal Diversity Research Series, 5, 1–207.

Petrini LE. 2013a. Nomenclatural novelties : Liliane Petrini. Index Fungorum 25: 1–6,.

Petrini LE. 2013b. *Rosellinia* – a world monograph. Bibliotheca Mycologica 205. 410 p.

Tai FL. 1979. Sylloge Fungorum Sinicorum. Science Press, Beijing. 1527 p.

Teng SC. 1963. Fungi of China. Science Press, Beijing. 808 p.

Yuan ZQ, Zhao ZY. 1993. Studies on the Genera *Amphisphaerella*, *Coniochaeta* and *Rosellinia* of XingJiang, China. Acta Mycologica Sinica 12(3): 180–186.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 547–551

http://dx.doi.org/10.5248/131.547

Phaeomonilia nanningensis sp. nov. and a new *Craspedodidymum* record from southern China

Chun-Ling Yang, Jin-Ye Wang, Ji-Wen Xia,
Ying-Rui Ma, Jian-Mei Gao & Xiu-Guo Zhang*

Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong 271018, China

*Correspondence to: *sdau613@163.com, zhxg@sdau.edu.cn*

Abstract—A new species, *Phaeomonilia nanningensis*, is described and illustrated from specimens collected on dead branches in Guangxi Province. The fungus is characterized by ellipsoid, catenate, pale brown to brown conidia formed by thallic disarticulation of fertile branches on macronematous conidiophores. A key to the four described species of *Phaeomonilia* is also provided. *Craspedodidymum abigianense* is newly recorded from China.

Key words—conidial fungi, taxonomy

Introduction

Phaeomonilia was established by Castañeda-Ruíz et al. (2007) with two species: *P. pleiomorpha* R.F. Castañeda et al. (type species) and *P. corticola* (R.F. Castañeda) R.F. Castañeda et al. [≡ *Monilia corticola* R.F. Castañeda]. Subsequently, Ma et al. (2015) described a third species, *P. guangxiensis* Y.R. Ma & X.G. Zhang. The genus is mainly characterized by macronematous conidiophores with unicellular globose colorless conidia formed by thallic disarticulation of fertile branches and by the *Stylaspergillus*-like synanamorph. It is similar to *Botryomonilia* Goos & Piroz. (Goos & Pirozynski 1975) in its branching system, which narrows progressively towards the apex before the maturation, and the fragmentation or disarticulation process that produces the thallic–arthric conidia, as described by Kendrick (2003). *Botryomonilia*, however, produces conidia that are connected by an isthmus (Castañeda-Ruíz et al. 2007).

During our ongoing survey of fungi associated with woody debris in the tropical forests of Guangxi and Hainan provinces, two species were collected

on decaying twigs and dead stems. One of them, with morphological characteristics of *Phaeomonilia* (Castañeda-Ruíz et al. 2007), is described here as a new species, *P. nanningensis;* the other was identified as *Craspedodidymum abigianense*, a new record for China. Voucher specimens are conserved in the Herbarium, Department of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP) and Herbarium Mycologium, Chinese Academy of Sciences, Beijing, China (HMAS).

Phaeomonilia nanningensis C.L. Yang & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 818085

Differs from *Phaeomonilia corticola* by its larger, ellipsoid conidia; and from *P. guangxiensis* by its larger, pale brown to brown , ellipsoid conidia.

Type: China, Guangxi Province, Nanning, Longhushan, on dead stems of unidentified broadleaf tree, 8 Dec. 2015, C.L. Yang (**holotype**, HSAUP H7858; **isotype**, HMAS 245606).

Etymology: *nanningensis*, in reference to the type locality, Nanning.

Colonies on the natural substratum effuse, circumvolute, twinkling, brown. Mycelium mostly superficial but some immersed; superficial hyphae pale brown, branched, septate, cylindrical, smooth. Conidiophores macronematous, mononematous, erect, straight or flexuous, cylindrical, septate, smooth, about 410 µm long, 9–10.5 µm diam. at the base, brown to pale brown, mostly dichotomously branched towards the apex. Conidiogenous cells holothallic, determinate, inwardly brown to pale brown, smooth, lageniform to subulate. Ramoconidia and conidia thallic-arthric, catenate, ellipsoid, broadly and more or less Y-shaped, 13.5–25 × 9–13 µm, brown to pale brown, dry, smooth, forming by disarticulation of the conidiogenous branches.

Comments – *Phaeomonilia nanningensis* slightly resembles *P. corticola* and *P. guangxiensis* in conidial shape. However, compared with *P. nanningensis*, the conidia of *P. corticola* are ellipsoid to doliiform and smaller (5.5–16.0 × 4–5 µm; Castañeda-Ruíz et al. 2007); and the conidia of *P. guangxiensis* are colorless, ellipsoid to globose, and smaller (11–14.5 × 7–11 µm; Ma & Zhang 2015).

Key to species of *Phaeomonilia*

1. *Stylaspergillus*-like synanamorph present ..... *P. pleiomorpha*
1. No synanamorph present 2
2. Conidia globose, 7–11 × 11–14.5 µm ..... *P. guangxiensis*
2. Conidia doliiform or ellipsoid 3
3. Conidia doliiform or ellipsoid, 5.5–16 × 4–5 µm ..... *P. corticola*
3. Conidia ellipsoid and larger, 13.5–25 × 9–13 µm ..... *P. nanningensis*

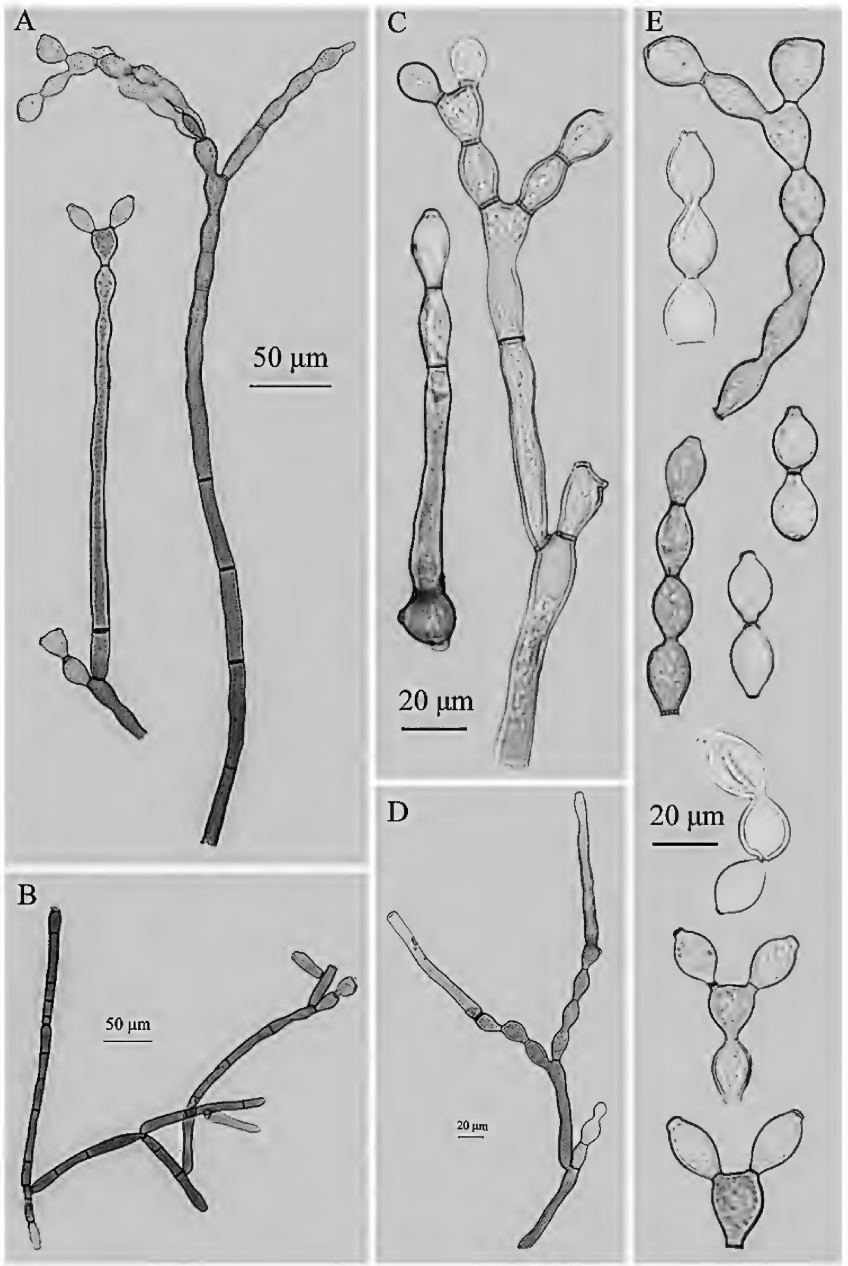


Fig. 1. *Phaeomonilia nanningensis* (holotype, HSAUP H7858).
A, B. conidiophores and conidia. C, D. conidiogenous cells and conidia. E. conidia.

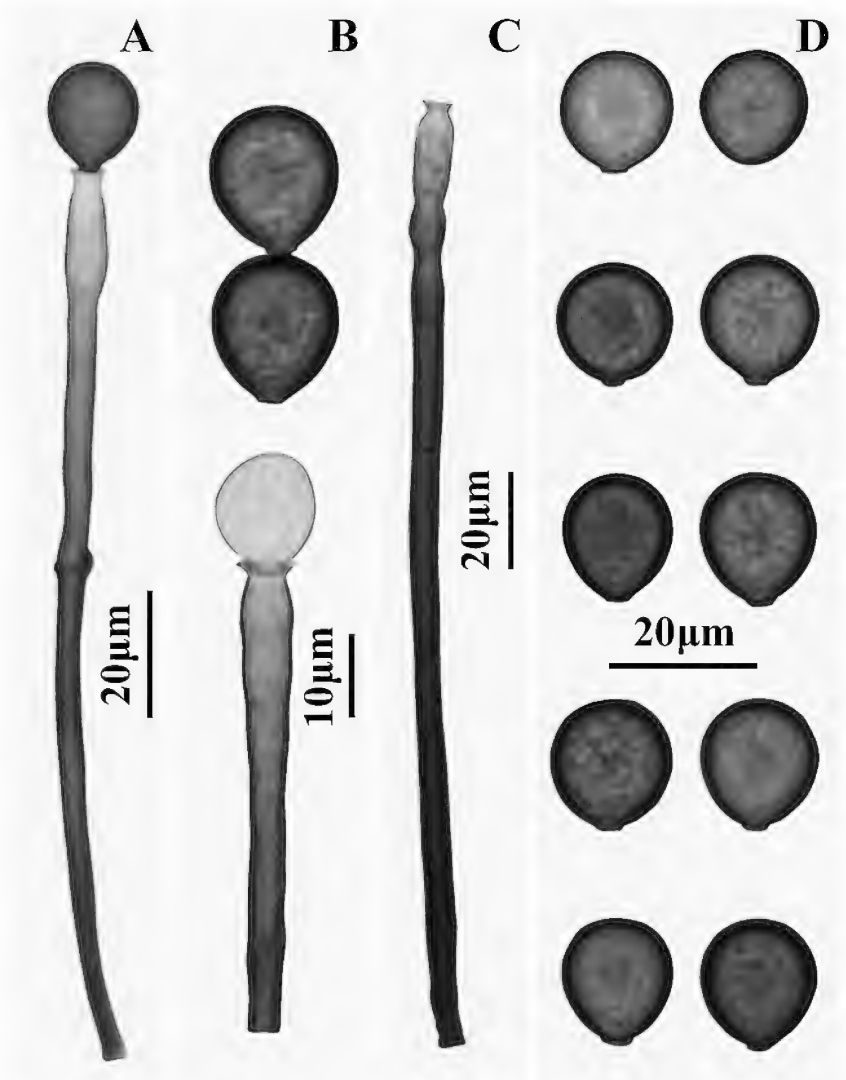


Fig. 2. *Craspedodidymum abigianense* (HSAUP H7566).
A: conidiophore and conidium. B: conidiogenous cell and conidia. C: conidiophore. D: conidia.

Craspedodidymum abigianense Lunghini & Onofri, Trans. Br. Mycol. Soc. 74: 208 (1980) Fig. 2

Colonies on the natural substratum effuse, dark brown. Conidiophores macronematous, mononematous, straight or slightly flexuous, dark brown,

4–6-septate, 120–170 × 5.2–7 μm, tapered gradually towards the apex. Conidiogenous cells terminal, ellipsoidal, monophialidic or rarely polyphialidic, percurrent, 20–30 × 6.5–8 μm, paler brown, with a distinct funnel-shaped collarette, 1.5–2.0 × 5.5–7.5 μm. Conidia acrogenous, solitary, spherical or more often obovoid, smooth, dark brown, generally paler when young, aseptate, 15.5–18.5 × 5.5–16.5 μm, papillate at the base.

Specimen Examined: **CHINA**, **Hainan Province**, Diaoluoshan, on dead stems of unidentified broadleaf tree, 26 May 2014, X.Y. Li (HSAUP H7566).

Comments – The genus *Craspedodidymum* was established by Holubová-Jechová (1972), with *C. elatum* Hol.-Jech. as type species. *Craspedodidymum abigianense,* described by Lunghini & Onofri (1980) from Côte d'Ivoire, West Africa, is reported for the first time from China. Our Chinese specimen closely matched the original description by Lunghini & Onofri (1980), but the type material had longer conidiophores (225–250 × 4.5–5.5 μm) and conidia that were smaller (14.5–16.5 × 13.5–14.5 μm) and slightly lighter in colour.

Acknowledgments

The authors express gratitude to Dr. Rafael F. Castañeda-Ruiz and Dr. Eric H.C. McKenzie for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 31093440, 31230001, 31493010, 31493011) and the Ministry of Science and Technology of the People's Republic of China (Nos. 2006FY120100).

Literature cited

Castañeda-Ruíz RF, Heredia-Abarca G, Arias RM, Saikawa M, Minter DW, Stadler M. 2007. Anamorphic fungi from submerged plant material: *Phaeomonilia pleiomorpha*, *P. corticola* and *Cacumisporium pleuroconidiophorum.* Mycotaxon 100: 327–336.

Goos RD, Pirozynski KA. 1975. Fungi of Barro Colorado Island: new and interesting hyphomycetes. Canadian Journal of Botany 53: 2927–2932. http://dx.doi.org/10.1139/b75-322

Holubová-Jechová V. 1972. *Craspedodidymum*, new genus of phialosporus hyphomycetes. Česká Mykologie 26: 70–73.

Kendrick B. 2003. Analysis of morphogenesis in hyphomycetes: new characters derived from considering some conidiophores and conidia as condensed hyphal systems. Canadian Journal of Botany 81: 75–100. http://dx.doi.org/10.1139/b03-008

Lunghini D, Onofri S. 1980. *Craspedodidymum abigianense* sp. nov., a new dematiaceous Hyphomycete from Ivory Coast forest litter. Transactions of the British Mycological Society 74: 208–211. http://dx.doi.org/10.1016/S0007-1536(80)80033-7

Ma YR, Xia JW, Zhang XG, Castañeda-Ruiz RF. 2015. New species of *Phaeomonilia* and *Mirandina* from dead branches in China. Mycotaxon 130: 775–781. http://dx.doi.org/10.5248/130.775

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 553–558

http://dx.doi.org/10.5248/131.553

Pseudoacrodictys from southern China: *P. ambigua* sp. nov. and a new record

Jian-Mei Gao, Jin-Ye Wang, Chun-Ling Yang, Ji-Wen Xia, Ying-Rui Ma & Xiu-Guo Zhang*

Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong 271018, China

*Correspondence to: *sdau613@163.com, zhxg@sdau.edu.cn*

Abstract—Two species of *Pseudoacrodictys* were discovered from tropical forests in southern China. One new species, *P. ambigua*, is described and compared with closely related taxa, and *P. magnicornuata* is newly recorded from China.

Key words—hyphomycetes, taxonomy

Introduction

The genus *Pseudoacrodictys*, typified by *Acrodictys eickeri* [≡ *P. eickeri*], was erected by Baker & Morgan-Jones (2003) to accommodate seven species of *Acrodictys*. Subsequently, seven additional *Pseudoacrodictys* species have been described (Somrithipol & Jones 2003, Castañeda-Ruíz et al. 2010, Zhang et al. 2011, Rashmi & Pandey 2012, Fiuza et al. 2014, Ma et al. 2016). The genus is characterized by single, straight or slightly flexuous, thick-walled, cylindrical, aseptate or septate, brown to dark blackish-brown conidiophores with an integrated, terminal, monoblastic, cylindrical, determinate or (more commonly) indeterminate with percurrent elongate conidiogenous cells and schizolytic conidial secession. Conidia, which are holoblastic, solitary, acrogenous, subglobose, broadly pyriform to turbinate or somewhat irregularly shaped, dictyoseptate with numerous obliquely arranged septa, and brown to dark brown, commonly possess pale brown, aseptate or septate, straight, undulate, involute to uncinate appendages.

During our ongoing survey of microfungi associated with plant debris in tropical and subtropical forests of southern China, two species with the

Table 1. Morphological comparison of *Pseudoacrodictys* species with appendaged conidia

Species	Conidia		Appendages		
	Shape	Size (μm)	Number	Length (μm)	Shape
P. ambigua	Obclavate or irregular, sometimes lobed	70–95 × 25–90	2–5	40–130	Subulate
P. appendiculata	Pyriform to turbinate	27–45 × 22–30	2–3	56	Subulate
P. balansae	Subnapiform, turbinate to irreg. subglobose, sometimes lobed	42–68 × 28–62	6–20	10–30	Curved, undulate, swollen
P. corniculata	Globose, subglobose, or broadly pyriform	19–35 × 7–30	3–4	8–20	Subulate, curved
P. eickeri	Pyriform to turbinate	28–64 × 22–42	3–4	7–12	Cylindrical
P. fici	Subglobose, sometimes lobed	35–52 × 22–44	2–4	30–70	Cylindrical
P. limoniaceae	Turbinate to obpyriform	21–34 × 3–33	1–8	6–17	Curved, horn-like
P. magnicornuata	Turbinate, subnapiform, subglobose, or irregular	50–87 × 50–67	9–35	18–50	Circinate
P. viridescens	Globose, subglobose, or broadly pyriform	62–80 × 40–60	4–6	8–20	Cylindrical

morphological characteristics of *Pseudoacrodictys* were collected on decaying twigs and dead stems: *P. ambigua* is proposed here as new to science, and *P. magnicornuata* represents a new record for China. Voucher specimens are conserved in the Herbarium, Department of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP) and Herbarium Mycologium, Chinese Academy of Sciences, Beijing, China (HMAS).

Pseudoacrodictys ambigua J.M. Gao & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 818098

Differs from all other *Pseudoacrodictys* species with appendaged conidia by its larger, obclavate or irregular, and sometimes lobed conidia and its longer conidial appendages.

Type: China. Yunnan Province: tropical forest of Menglun, on dead stems of unidentified broadleaf tree, 20 Dec. 2014, J.M. Gao (**holotype**, HSAUP H9624; **isotype**, HMAS 245608).

Etymology: *ambigua,* referring to the numerous obscure oblique conidial septa.

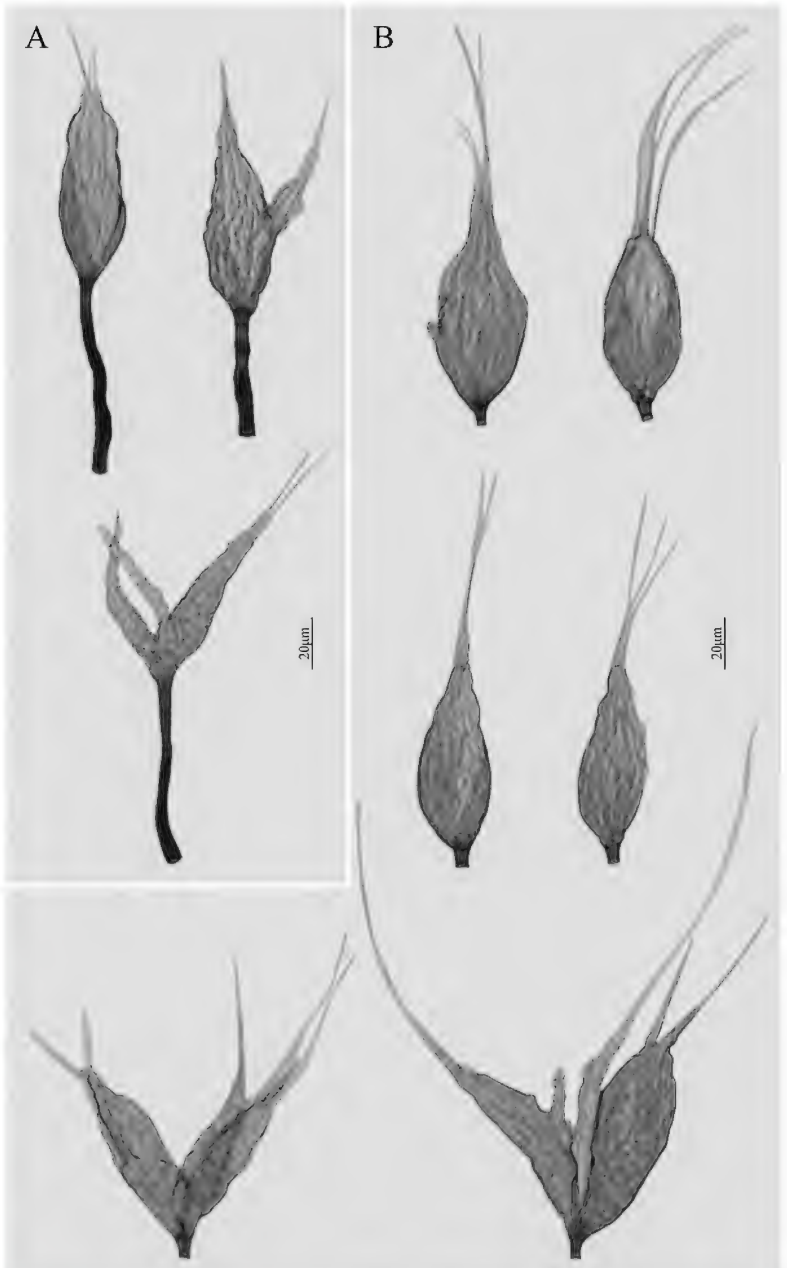


Fig. 1. *Pseudoacrodictys ambigua* (holotype, HSAUP H9624).
A. conidiophores, conidiogenous cells and conidia. B. conidia.

Colonies on natural substrate effuse, dark brown. Mycelium superficial and immersed, composed of branched, septate, brown hyphae. Conidiophores macronematous, mononematous, erect, straight or flexuous, septate, brown to dark brown, 45–75 × 3.5–7 μm. Conidiogenous cells integrated, terminal, cylindrical, monoblastic, indeterminate, with 1–2 percurrent elongations, smooth, dark brown, truncate at the apex after schizolytic conidial secession. Conidia acrogenous, holoblastic, solitary, dry, obclavate or irregular, dictyosporous, with numerous obscure oblique septa, thick-walled, sometimes lobed, brown, 70–95 × 25–90 μm. Basal cell cylindrical, delimited by a transverse, cambered septum, 6.0–7.0 × 3.5–5.0 μm. Appendages 2–5, aseptate, pale brown, straight or slightly flexuous, ≤130 μm long, 0.5–1.5 μm diam. at the conidial apex.

Comments—*Pseudoacrodictys* species with appendaged conidia are compared in Table 1; the other eight species all differ from *P. ambigua* by their smaller conidia with shorter appendages.

Pseudoacrodictys magnicornuata Fiuza, Gusmão & R.F. Castañeda-Ruiz, Mycotaxon 127: 36 (2014) Fig. 2

Colonies on natural substrate effuse, dark brown. Mycelium superficial and immersed, composed of branched, septate, brown hyphae. Conidiophores macronematous, mononematous, erect, straight or slightly flexuous, 3–5-septate, brown to dark brown, 40–65 × 4–6 μm, 6–7.5 μm diam. at the base. Conidiogenous cells integrated, terminal, cylindrical, monoblastic, indeterminate, with 1–2 percurrent extensions, smooth, brown, truncate at the apex. Conidia holoblastic, acrogenous, solitary, turbinate, subnapiform, subglobose, or somewhat irregularly shaped, dictyoseptate and with several obscure septa, thick-walled, brown, 40–70 × 30–55 μm, seceding schizolytically, the basal cell 2.5–3.5 μm diam. and delimited by a transverse, cambered septum. Appendages 9–20, aseptate, curly, undulate, swollen, pale brown, 8–30 × 3–6 μm, scattered around the conidia.

Specimen examined: **China, Yunnan Province**, tropical forest of Dadugang, on dead stems of unidentified broadleaf tree, 22 Dec. 2014, J.M. Gao (HSAUP H9677).

Comments—*Pseudoacrodictys magnicornuata*, which was described from Brazil, is reported for the first time from China. The Chinese specimen closely matched the protologue description (Fiuza et al. 2014), except that the Brazilian type specimen had more (9–35) appendages.

Acknowledgments

The authors express gratitude to Dr. Rafael F. Castañeda-Ruiz and Dr. De-Wei Li for serving as pre-submission reviewers and for their valuable comments and suggestions.

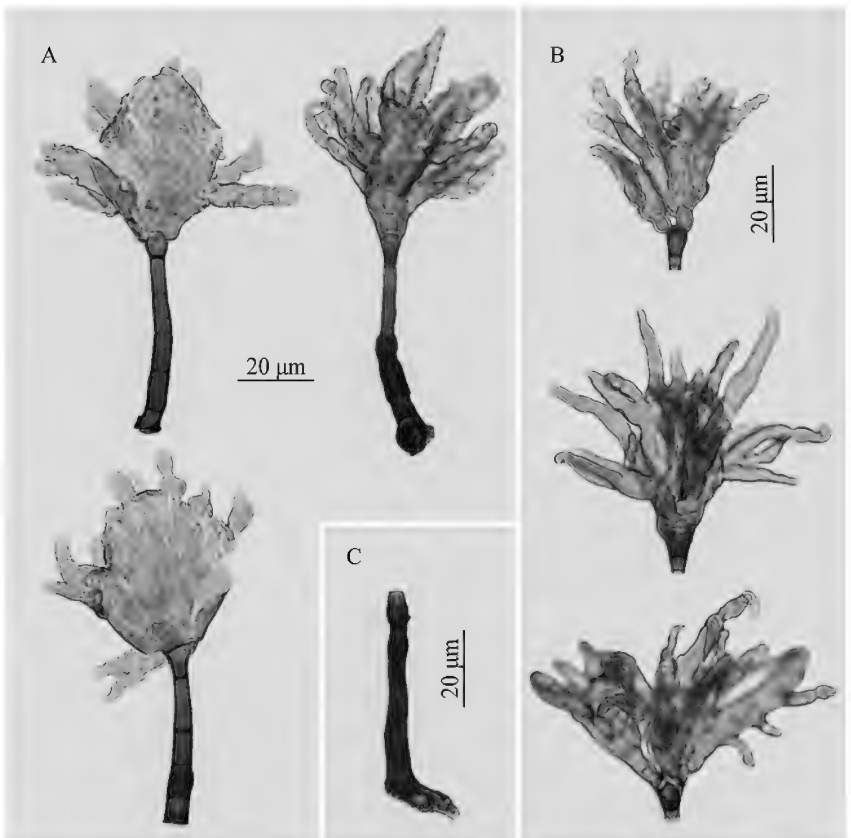


Fig. 2. *Pseudoacrodictys magnicornuata* (HSAUP H9677).
A. conidiophores, conidiogenous cells and conidia. B. conidia.
C. conidiophore and conidiogenous cell.

This project was supported by the National Natural Science Foundation of China (Nos. 31093440, 31230001, 31493010, 31493011) and the Ministry of Science and Technology of China (Nos. 2006FY120100).

Literature cited

Baker WA, Morgan-Jones G. 2003. Notes on Hyphomycetes. XCI. *Pseudoacrodictys*, a novel genus for seven taxa formerly placed in *Acrodictys*. Mycotaxon 85: 371–391.

Castañeda-Ruiz RF, Heredia Abarca G, Arias RM, Stadler M, Saikawa M, Minter DW. 2010. *Anaselenosporella sylvatica* gen. & sp. nov. and *Pseudoacrodictys aquatica* sp. nov., two new anamorphic fungi from Mexico. Mycotaxon 112: 65–74. http://dx.doi.org/10.5248/112.65

Fiuza PO, Gusmão, LFP, Cruz ACR, Castañeda-Ruiz RF. 2014. Conidial fungi from semiarid Caatinga biome of Brazil: a new species of *Pseudoacrodictys*. Mycotaxon 127: 33–37. http://dx.doi.org/10.5248/127.33

Ma YR, Xia JW, Castañeda-Ruíz RF, Zhang XG. 2016. Two new species of *Pseudoacrodictys* from Hainan, China. Nova Hedwigia 102: 69–75. http://dx.doi.org/10.1127/nova_hedwigia/2015/0303

Rashmi D, AK Pandey. 2012. *Pseudoacrodictys steviae* – a new generic and species record for India. Journal of Mycology and Plant Pathology 42: 251–253.

Somrithipol S, Jones EBG. 2003. *Pseudoacrodictys dimorphospora* sp. nov., a new graminicolous hyphomycete from Thailand. Sydowia 55(2): 365–371.

Zhang YD, Ma J, Wang Y, Ma LG, Castañeda Ruíz RF, Zhang XG. 2011. New species and record of *Pseudoacrodictys* from southern China. Mycological Progress 10: 261–265. http://dx.doi.org/10.1007/s1157-010-0696-z

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 559–563

http://dx.doi.org/10.5248/131.559

Capsicispora mycophila gen. & sp. nov. from southern China

Jin-Ye Wang[1], Chun-Ling Yang[2], Ji-Wen Xia[2], Ying-Rui Ma[2], Jian-Mei Gao[2], Yu-Mei Cai[1*] & Xiu-Guo Zhang[2]

[1] *College of Animal Science and Veterinary Medicine, Shandong Agricultural University & Sino-German Cooperative Research Centre for Zoonosis of Animal Origin Shandong Province, Taian, Shandong, China*

[2] *Department of Plant Pathology, Shandong Agricultural University, Taian, 271018, China*

*Correspondence to: *sdau613@163.com, caiyum@163.com*

Abstract—A new hyphomycete genus and species, *Capsicispora mycophila*, is described and illustrated. *Capsicispora* is characterized by mycophilic mycelium and mononematous, hyaline, determinate conidiophores with monoblastic, terminal conidiogenous cells and schizolytic secession of solitary, hyaline conidia. A key to *Capsicispora* and morphologically similar genera is provided.

Key words—conidial fungi, hyperparasite, taxonomy

Introduction

Saprobic hyphomycetes are highly diverse on plant material and numerous new taxa have been recently discovered (Zhang et al. 2009, Ren et al. 2012, Li et al. 2012, Ma et al. 2014, Xia et al. 2014). During our ongoing surveys of saprobic fungi associated with woody debris in subtropical forests of Henan province, an undescribed mycophilic fungus was collected overgrowing the conidiophores and conidia of *Ellisembia camelliae-japonicae* (Wu & Zhuang 2005). Detailed studies of its morphology and development revealed that it could not be accommodated in any previously described genus (Carmichael et al. 1980; Subramanian 1971; Ellis 1971, 1976; Matsushima 1975, 1983, 1985, 1993, 1995; Castañeda-Ruiz & Kendrick 1990, 1991; Wu & Zhuang 2005). For that reason, we describe a new genus for this unknown fungus.

Material & methods

Samples were processed, examined, and photographed as described in Xia et al. (2014). Adobe Photoshop 7.0 was used to process images into compound photographs; backgrounds were modified for esthetic reasons. We were unable to culture this species and so no molecular data are presented here. The specimens are deposited in the Herbarium of Department of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP) and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Capsicispora J.Y. Wang, Yu M. Cai & X.G. Zhang, **gen. nov.**

MycoBank MB 818082

Differs from *Capsicumyces* by its mycophilic habit and its schizolytic conidial secession.

Type Species: *Capsicispora mycophila* J.Y. Wang et al.

Etymology: Referring to the conidial shape is similar to *Capsicumyces*.

Mycelium mycophilic. Conidiophores macronematous, mononematous, hyaline, unbranched, erect. Conidiogenous cells monoblastic, integrated, terminal, hyaline, determinate. Conidial secession schizolytic. Conidia solitary, hyaline.

Capsicispora mycophila J.Y. Wang, Yu M. Cai & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 818083

Differs from *Capsicumyces delicatus* by its mycophilic habit, its schizolytic conidial secession, and its predominantly navicular or fusiform conidia with an apical mucilaginous sheath.

Type: China, Henan Province, Liankangshan, on conidiophores and conidia of *Ellisembia camelliae-japonicae* (Subram.) W.P. Wu growing on dead branches of unidentified broadleaf tree, 16 Oct. 2015, J.Y. Wang (**Holotype**, HSAUP H10083; **isotype**, HMAS 245607).

Etymology: From Greek *myco* = fungus, and *philus* = loving, indicating its occurrence on other fungi.

Colonies on the natural substrate effuse, hyaline, very thin, scarcely visible, overgrowing *Ellisembia camelliae-japonicae* colonies (especially overgrowing the conidia). Mycelium creeping, mycophilic, superficial, repent, apparently aseptate or rarely septate, hyaline, smooth, 1–2 µm wide. Conidiophores mononematous, hyaline, simple, erect, aseptate, narrowly truncate at the apex, 9–16 × 2–4 µm. Conidiogenous cells integrated, terminal, monoblastic, hyaline. Conidial secession schizolytic. Conidia solitary, hyaline, 0–1-septate, smooth, fusiform, navicular or obclavate, 20–30 µm long, 4–4.6 µm diam. at the broadest part, with a short, protruding truncate hilum at the base, attenuated towards the apex, apex often surrounded by a hyaline, globose mucilaginous sheath.

Fig. 1. *Capsicispora mycophila.* (ex holotype, HSAUP H10083): A. Four conidiophores (and one developing conidium). B. Habit on substrate (*Ellisembia camelliae-japonicae* – dark conidiophores and phragmoconidia): conidiophores, conidiogenous cells, and conidia. C. Conidia.

Comments – *Capsicispora* demonstrates unique features in morphology and ontogeny. Several existing genera (e.g., *Capsicumyces*, *Eriomycopsis*, *Parachionomyces*, *Paratrichoconis*, and *Soloacrospora*) have morphological characters that resemble those of *Capsicispora* (Spegazzini 1910, Ciferri 1954, Deighton & Pirozynski 1972, Gamundí et al. 1979, Thaung 1979, Castañeda-Ruiz & Kendrick 1991, Braun 1994, Castañeda-Ruiz et al. 1997, Braun & Mel'nik 1998). However, in *Eriomycopsis*, conidiophores are indeterminate with sympodial proliferations and the conidia are rostrate, while in *Capsicispora* the conidiogenous cells are determinate and the conidia lack a rostrum. Septate branched geniculate conidiophores, polyblastic conidiogenous cells, and rostrate conidia separate *Parachionomyces* from *Capsicispora*. *Paratrichoconis* and *Capsicumyces* can be distinguished from *Capsicispora* by their non-mycophilic mycelium and rhexolytic conidia secession. The whip-like setae, non-mycophilic mycelium, pale brown conidiophores of *Soloacrospora* clearly separate that genus from *Capsicispora* with its mycophilic mycelium, hyaline conidiophores, and absence of setae.

Key to *Capsicispora* and morphologically similar genera

1. Mycelium mycophilic ('hyperparasitic') 2
1. Mycelium non-mycophilic 4
2. Conidia rostrate 3
2. Conidia not rostrate ..... *Capsicispora*
3. Conidiophores branched ..... *Parachionomyces*
3. Conidiophores unbranched ..... *Eriomycopsis*
4. Setae present ..... *Soloacrospora*
4. Setae absent 5
5. Conidial secession schizolytic ..... *Capsicumyces*
5. Conidial secession rhexolytic ..... *Paratrichoconis*

Acknowledgments

The authors express gratitude to Dr. Rafael F. Castañeda-Ruiz and Dr. Eric H.C. McKenzie for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 31093440, 31230001, 31493010, 31493011) and the Ministry of Science and Technology of the People's Republic of China (Nos. 2006FY120100).

Literature cited

Braun U. 1994. Miscellaneous notes on phytopathogenic hyphomycetes. Mycotaxon 51: 37–68.

Braun U, Mel'nik VA. 1998. *Eriomycopsis lasiosphaeriicola* sp. nov. A new hyperparasitic hyphomycete fom the Far East of Russia. Mikologiya i Fitopatologiya 32(1): 3–6.

Carmichael JW, Kendrick WB, Conners IL, Sigler YL. 1980. Genera of hyphomycetes. University of Alberta Press, Alberta. 386 p.

Castañeda-Ruiz RF, Kendrick WB. 1990. Conidial fungi from Cuba: I. University of Waterloo Biology Series 32. 53 p.

Castañeda-Ruiz RF, Kendrick WB. 1991. Ninety-nine conidial fungi from Cuba and three from Canada. University of Waterloo Biology Series 35. 132 p.

Castañeda-Ruiz RF, Guarro J, Cano J. 1997. Notes on conidial fungi. XII. New or interesting hyphomycetes from Cuba. Mycotaxon 63: 169–181.

Ciferri R. 1954. Schedae Mycologicae XII–XXXIV. Sydowia 8: 245–270.

Deighton FC, Pirozynski KA. 1972. Microfungi V. More hyperparasitic hyphomycetes. Mycological Papers 128. 110 p.

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew. 608 p.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew. 507 p.

Gamundí IJ, Arambarri AM, Bucsinszky AM. 1979. Micoflora de la hojarasca de *Nothofagus dombeyi*, II. Darwiniana 22(1–3): 189–216.

Li DW, Kendrick B, Chen JY. 2012. Two new hyphomycetes: *Codinaea sinensis* sp. nov. and *Parapleurotheciopsis quercicola* sp. nov., and two new records from *Quercus phillyraeoides* leaf litter. Mycological Progress 11: 899–905. http://dx.doi.org/10.1007/s11557-011-0805-7

Ma LG, Xia JW, Ma YR, Castañeda-Ruiz RF, Zhang XG. 2014. Two new species of *Spadicoides* and *Gangliostilbe* from southern China. Mycological Progress 13: 547–552. http://dx.doi.org/10.1007/s11557-013-0937-z

Matsushima T. 1975. Icones microfungorum a Matsushima lectorum. Published by the author: Kobe, Japan. 209 p.

Matsushima T. 1983. Matsushima Mycological Memoirs No.3. Published by the author, Kobe, Japan. 89 p.

Matsushima T. 1985. Matsushima Mycological Memoirs No.4. Published by the author, Kobe, Japan. 68 p.

Matsushima T. 1993. Matsushima Mycological Memoirs No.7. Published by the author, Kobe, Japan. 75 p.

Matsushima T. 1995. Matsushima Mycological Memoirs No.8. Published by the author, Kobe, Japan. 54 p.

Ren SC, Ma J, Zhang XG. 2012. *Sativumoides* and *Cladosporiopsis*, two new genera of hyphomycetes from China. Mycologia 11: 443–448. http://dx.doi.org/10.1007/s11557-011-0759-9

Spegazzini C. 1910. Mycetes argentinenses (series V). Anales del Museo Nacional de Historia Natural Buenos Aires 20: 329–467.

Subramanian CV. 1971. Hyphomycetes. An account of Indian species, expect Cercosporae. Indian Council of Agricultural Research, New Delhi. 930 p.

Thaung MM. 1979. Two new microfungi from Burma. Transactions of the British Mycological Society 72: 333–336.

Wu WP, Zhuang WY. 2005. *Sporidesmium, Endophragmiella* and related genera from China. Fungal Diversity Research Series 15: 1–351.

Xia JW, Ma LG, Castañeda-Ruiz RF, Zhang XG. 2014. *Minimelanolocus bicolorata* sp. nov., *Paradendryphiopsis elegans* sp. nov. and *Corynesporella bannaense* sp. nov. from southern China. Mycoscience 55: 299–307. http://dx.doi.org/10.1016/j.myc.2013.11.003

Zhang K, Ma LG, Zhang XG. 2009. New species and records of *Shrungabeeja* from southern China. Mycologia 101: 573–578. http://dx.doi.org/10.3852/09-006

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 565–574

http://dx.doi.org/10.5248/131.565

Diploschistes tianshanensis sp. nov., a corticolous species from Northwestern China

Gulibahaer Ababaikeli[1], Abdulla Abbas[1*A], Shou-Yu Guo[2*B], Aniwaer Tumier[1] & Reyimu Mamuti[1]

[1] *Arid Land Lichen Research Center of Western China, College of Life Science & Technology, Xinjiang University, Urumqi 830046, P. R. China*

[2] *State Key Laboratory of Mycology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, P. R. China*

[*]Correspondence to: [A]*Abdulla@xju.edu.cn* [B]*guosy@im.ac.cn*

Abstract—*Diploschistes tianshanensis* is described as a new species, found on rotten wood with mosses and other lichens (*Cladonia* sp.) in an arid region of Northwestern China. The new fungus, which is diagnosed by urceolate ascomata and large ascospores, resembles *D. gypsaceus* but is readily distinguished by its epruinose thallus surface. ITS rDNA sequence analyses support the taxon as a distinct species. The description of *D. tianshanensis* is accompanied by notes on its chemistry, distribution and ecology, and comparison with related species.

Key words—Central Asia, biodiversity, *Graphidaceae*, *Ostropales*, taxonomy

Introduction

Diploschistes Norman includes crustose lichens with a blackish pseudoparenchymatous proper exciple, lateral paraphyses, and a trebouxioid photobiont (Lumbsch 1989, Lumbsch & Mangold 2007). The genus is widely distributed in arid and semiarid regions worldwide and comprises 35–44 species (Pérez-Vargas et al. 2012, Fernández-Brime et al. 2013, Abbas et al. 2014). Most *Diploschistes* species occur on rocks, some on soil, and a few species are rarely found on wood or bark (Lumbsch & Mangold 2007). After Lumbsch (1989) monographed Holarctic species, several papers on *Diploschistes* were published covering cladistic analysis and molecular phylogeny (Lumbsch & Tehler 1998, Martín et al. 2003, Fernández-Brime et al. 2013), ecology and distribution

(Pant & Upreti 1993, Guderley & Lumbsch 1996, Lumbsch & Elix 2003, Mangold et al. 2009), and taxonomy including new species and combinations (Lumbsch & Elix 1985, 1989; Lumbsch & Mayrhofer 1990; Lumbsch & Aptroot 1993; Lumbsch & Mangold 2007; Pérez-Vargas et al. 2012; Abbas et al. 2014). The genus exhibits a remarkably variable morphology of the ascomata, which vary from perithecioid to urceolate and lecanoroid (Lumbsch 1989, Lumbsch & Mangold 2007). Despite this variation, *Diploschistes* is currently regarded as monophyletic and accommodated within the *Graphidaceae* (*Ostropales*) based on molecular studies (Frisch et al. 2006, Martín et al. 2003, Fernández-Brime et al. 2013).

The lichen biota of Northwestern China is rich, with more than 670 species (in 127 genera) previously reported (Abbas & Wu 1998, Guo 2005). Nevertheless, lichen diversity is still incompletely known in the region and new species can be expected to continue to be described. Of the nine *Diploschistes* species recorded from China, four were described from the Northwestern region (Wei 1991, Guo 2005, Abbas et al. 2014).

An additional *Diploschistes* species recently collected in Xinjiang, Northwestern China, is described here as *D. tianshanensis*, based on morphological and chemical characters. The ITS region of nrDNA of the type specimen has also been sequenced and compared with GenBank sequences to assess the phylogenetic affinities of the new species.

Materials & methods

The specimens studied were collected from Mountain Tianshan, Xinjiang, China, and deposited in the Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L) and the Lichen Section of Botanical Herbarium, Xinjiang University, Urumqi, China (XJU). Their morphology was examined using a Zeiss Stemi SV 11 stereomicroscope. Sections for anatomical examination were cut by hand using a razor blade, mounted in water, studied with a Zeiss Axioskop 2 plus light microscope, and photographed using a Nikon Digital Camera D50. Chemical constituents were identified by thin-layer chromatography using solvent systems A, B and C (Orange et al. 2010).

DNA extraction, amplification, and sequencing. DNA was extracted from thallus fragments with ascomata of the type specimen using the DNAsecure Plant DNA Kit (Tiangen, China) following the manufacturer's protocol. The ITS region was amplified according to Martín et al. (2003) and Abbas et al. (2014). The entire ITS region (ITS1+5.8S+ITS2) of the nrDNA repeat tandem was targeted for the Polymerase Chain Reaction amplification using the primers ITS1 and ITS4 (White et al. 1990) and performed in a 25μL volume containing 0.75 units of TransStart Taq Polymerase (Tiangen, China), 2.5 μL of the buffer, 0.5 μL of a 5 μM solution of the primers, 2 μL of 2.5 mM for each dNTP solution, and 1 μL of genomic DNA. Thermocycling protocols

were 95°C for 3 min linked to 35 cycles at 94°C for 30 s, 54°C for 30 s, and 72°C for 1 min, with a final extension of 72°C for 10 min. The PCR products were screened on 1% agarose gels stained with ethidium bromide and sequenced by Genewiz Inc. (Beijing, China).

Newly obtained sequences were submitted to GenBank. The sequences were annotated according to Abbas et al. (2014). We excluded the 3′ end of the 18S (SSU) gene, and the 5′ end of the 28S (LSU) gene from the analyses. Sequences for the new species were complemented with similar *Diploschistes* taxa for which ITS sequences were available in GenBank (Table 1). Representative taxa were selected based on morphological characters, the results of Blast searches of ITS sequence, and the literature (Martín et al. 2003, Fernández-Brime et al. 2013, Abbas et al. 2014).

Table 1. GenBank accession numbers and voucher information for *Diploschistes tianshanensis* and 11 *Diploschistes* sequences downloaded from GenBank

Species	Voucher	GenBank
D. tianshanensis 1	China, Abbas 20s1	KC959951
D. tianshanensis 2	China, Abbas 20s2	KC959952
D. cinereocaesius	AFTOL-ID 328	HQ650715
D. diacapsis 1	Spain, BCC-Lich 13392	AF228317
D. diacapsis 2	Spain, BCC-Lich 13393	AF228318
D. gypsaceus	Switzerland, ESS-9047	AJ458284
D. gyrophoricus	Spain, BCC-Lich 11883	AJ458285
D. muscorum 1	Spain, BCC-Lich 13390	AF228319
D. muscorum 2	Spain, BCC-Lich 13391	AF229193
D. rampoddensis	Papua New Guinea, hb. Lumbsch	AJ458286
D. scruposus	Germany, ESS-21508	AJ458287
D. thunbergianus 1	Australia, hb. Lumbsch	AJ458289
D. thunbergianus 2	Australia, hb. Lumbsch	AJ458290

Phylogenetic analysis and sequence comparisons. The ITS sequences of the two examined samples and 11 selected representatives were aligned both by ClustalW and Muscle implemented in MEGA 5 (Tamura et al. 2011). The alignment matrix was realigned by StatAlign for reliable measurement of the accuracy of the results (Novák et al. 2008). The final matrix (submitted to TreeBase with accession number S14250) can be obtained from the corresponding authors.

The evolutionary history was inferred by using the Maximum Likelihood method (ML) based on the Tamura 3-parameter model in MEGA5 and Bayesian inference (PP) based on GTR model with rates = Invgamma. The analyses involved 13 nucleotide sequences. Absolute distances were also calculated in MEGA5, using the number of base differences between sequence pairs and with all gaps removed from each sequence pair.

Results & discussion

Sequence and phylogenetic analysis

The ITS1+5.8S+ITS2 region was successfully sequenced for the two Xinjiang samples, with the lengths varying by only one base pair (487–488 bp) for the entire region. The partial sequence containing SSU 3′ end and LSU 5′ end is included in the data submitted to GenBank.

A few positions in our sample sequences were difficult to align with the reference sequences and were excluded from the matrix. There were a total of 540 positions in the final dataset, all of which were used in the phylogenetic analyses.

The ITS sequences indicate that *D. tianshanensis* probably belongs to the *D. scruposus*-group (sensu Martín et al. 2003) with close affinities to the sub-cosmopolitan species, *D. diacapsis* (97% identity; 1% gap) and cosmopolitan species *D. gypsaceus* (96% identity; 1% gap) and *D. scruposus* (96% identity; 1% gap). The evolutionary history was inferred as the tree with the highest log likelihood (–1479.4326). The phylogenetic analyses strongly supported the monophyly of *D. tianshanensis* (ML = 100%; PP = 1) and *D. diacapsis* (ML = 97%; PP = 1) but only weakly supported (ML = 57%) the relationship

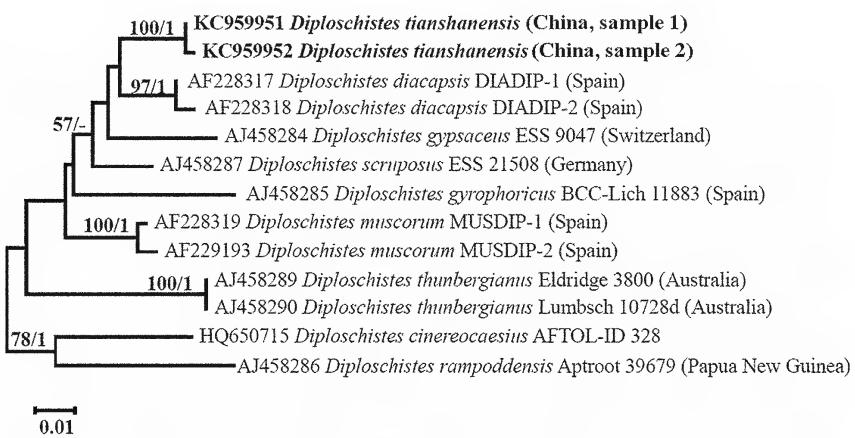

100/1
KC959951 Diploschistes tianshanensis (China, sample 1)
KC959952 Diploschistes tianshanensis (China, sample 2)
97/1
AF228317 Diploschistes diacapsis DIADIP-1 (Spain)
AF228318 Diploschistes diacapsis DIADIP-2 (Spain)
57/-
AJ458284 Diploschistes gypsaceus ESS 9047 (Switzerland)
AJ458287 Diploschistes scruposus ESS 21508 (Germany)
AJ458285 Diploschistes gyrophoricus BCC-Lich 11883 (Spain)
100/1
AF228319 Diploschistes muscorum MUSDIP-1 (Spain)
AF229193 Diploschistes muscorum MUSDIP-2 (Spain)
100/1
AJ458289 Diploschistes thunbergianus Eldridge 3800 (Australia)
AJ458290 Diploschistes thunbergianus Lumbsch 10728d (Australia)
78/1
HQ650715 Diploschistes cinereocaesius AFTOL-ID 328
AJ458286 Diploschistes rampoddensis Aptroot 39679 (Papua New Guinea)
0.01

FIGURE 1. Phylogenetic relationships inferred from ITS sequences of *Diploschistes tianshanensis* and some closely related species in the *D. scruposus* group (with *D. cinereocaesius* and *D. rampoddensis* as outgroup). Support is indicated for branches with Maximum Likelihood bootstrap frequencies >50%, and Bayesian Inference posterior probabilities >0.95. The evolutionary tree was inferred by using the Maximum Likelihood method based on the Tamura 3-parameter model. The tree with the highest log likelihood (–1479.4326) is shown. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site.

between *D. tianshanensis* and its morphologically closely related species including *D. diacapsis*, *D. gypsaceus*, and *D. scruposus* (Fig. 1).

Absolute distances for the aligned sequences of the ITS region also support the separation of a new species. In our sequence matrix, distances between infraspecific samples are ≤3 while distances between species are ≥13 (Table 2).

Table 2. Absolute distances between ITS sequences from *Diploschistes tianshanensis* and closely related species (gaps ignored in pairwise comparisons).
Infraspecific distances are indicated with **bold font**.

	1	2	3	4	5	6	7	8	9	10
1. *D. tianshanensis* 1										
2. *D. tianshanensis* 2	**1**									
3. *D. diacapsis* 1	13	14								
4. *D. diacapsis* 2	15	16	**2**							
5. *D. gypsaceus*	17	18	17	19						
6. *D. scruposus*	16	17	14	14	15					
7. *D. gyrophoricus*	25	26	24	25	26	24				
8. *D. muscorum* 1	19	20	20	20	22	14	24			
9. *D. muscorum* 2	20	21	21	20	22	14	25	**3**		
10. *D. thunbergianus* 1	31	32	29	29	35	28	35	26	27	
11. *D. thunbergianus* 2	31	32	29	29	35	28	35	26	27	**0**

Taxonomy

Diploschistes tianshanensis A. Abbas, S.Y. Guo & Ababaikeli, **sp. nov.** Figure 2

MycoBank MB 804328

Differs from *Diploschistes muscorum* by its grayish-green thallus without pruina and its larger ascospores.

Type: China. Xinjiang: Urumqi Co., Tianshan Mountain, Bayi forest farm, 43°21′N 86°49′E, alt. 1760 m, on rotten wood of *Picea schrenkiana* Fisch. & C.A. Mey., 27 Aug. 2011, A. Abbas 110821 (**Holotype**, HMAS-L; **isotype**, XJU; GenBank KC959951, KC959952).

Etymology: The specific epithet *tianshanensis* refers to the region in which the type specimen was collected.

Thallus corticolous, crustose, continuous, whitish-grey to grayish-green, moderately thin, ≤0.7 mm thick. Upper surface dull, without pruina. Medulla white, amyloid (I+ blue). Photobiont trebouxioid with cells ≤16 µm diam. Prothallus not visible. Vegetative propagules absent. Ascomata apothecia, immersed. Disc urceolate, without pruina, orbicular, 0.5–1.0 mm diam. Proper exciple dark brown, 60–100 µm thick. Hymenium hyaline, 120–180 µm high, not inspersed. Hypothecium yellowish brown,

Figure 2. *Diploschistes tianshanensis* (holotype, HMAS-L Abbas 110821).
A. habit; B. asci and mature ascospores. Scales: A = 2 mm; B = 20 μm.

15–30 µm thick. Paraphyses 1–2 µm thick, simple, apices not thickened. Asci cylindrical, 90–130 × 20–30 µm, 4-spored. Ascospores ellipsoid, brown, muriform, with 4–6 transverse and 1–2 longitudinal septa, 20–36(–42) × 12–18 µm. Pycnidia unknown.

Spot tests—K+ yellow, C+ and KC+ red, PD–.

Secondary metabolites—Diploschistesic and lecanoric acids detected (TLC).

Ecology—At present *D. tianshanensis* is known only from the type locality in Northwestern China. It grows on rotten wood of *Picea schrenkiana*, together with *Cladonia* sp. and mosses.

Additional specimen examined — **China. Xinjiang:** Urumqi, Tianshan Mountain, Bayi forest farm, 43°21′N 86°49′E, alt. 1800 m, 15 May 2010, A. Abbas 201000515 (XJU).

Comments —*Diploschistes tianshanensis* is characterized by its corticolous habit, grayish green appearance, absence of pruina, urceolate apothecia, large ascospores, and the presence of diploschistesic and lecanoric acids. To the best of our present knowledge, other *Diploschistes* species having a corticolous habitat include only *D. muscorum* (Scop.) R. Sant., which can be distinguished by its combination of 4-spored asci, juvenile parasitism, and the presence of grayish or whitish pruina. The new species resembles morphologically the cosmopolitan *D. gypsaceus* (Ach.) Zahlbr., which differs by its usual occurrence on calcareous substrata in shaded, damp habitats (Lumbsch 1988, Fletcher & Hawksworth 2009). *Diploschistes gypsaceus* has not yet been reported from China (Wei 1991, Guo 2005, Abbas et al. 2014).

Similar species also include *D. diacapsis* (Ach.) Lumbsch and *D. scruposus* (Schreb.) Norman. *Diploschistes diacapsis* is a terricolous species that is readily identified by its whitish pruinose thallus, (4–)8-spored asci, and the ascospore size (20–40 × 14–20 µm). *Diploschistes scruposus,* which is saxicolous but not corticolous, also has an epruinose thallus, (4–)8-spored asci, and may or may not contain diploschistesic acid. A comparison of the diagnostic characters of *D. tianshanensis* and morphologically similar species is provided in Table 3.

Previous studies that have used DNA sequence data for species recognition in lichens required both monophyly in single-locus ITS phylogenies and diagnosable morphological differences (e.g. Han et al. 2013, Abbas et al. 2014). Our morphological and molecular data for our new species meet the requirement for accurate species delimitation and support recognition of *Diploschistes tianshanensis* as a species new to science.

Acknowledgements

The authors thank Dr. Kerry Knudsen (The Herbarium, Department of Botany & Plant Sciences, University of California, Riverside, California 92521, U.S.A.) and Prof.

Table 3. Diagnostic comparisons of *Diploschistes tianshanensis* and closely related species

Species	Pruina	Ascomata	Asci	Spores (µm)	Habitat	Acids	Distribution
D. diacapsis	+ (whitish)	Urceolate–lecanoroid	4–8-spored	20–40 × 14–20	Terricolous/calciferous	Lecanoric, diploschistesic, orsellinic	Sub-cosmopolitan
D. gypsaceus	+	Urceolate	4-spored	30–34 × 15–18	Calciferous	Lecanoric, orsellinic	Cosmopolitan
D. muscorum	+ (grayish/whitish)	Urceolate	4-spored	18–32 × 6–15	Corticolous/terricolous	Lecanoric, diploschistesic	Cosmopolitan
D. scruposus	–	Urceolate	4–8-spored	25–40 × 10–20	Saxicolous	Lecanoric, diploschistesic	Cosmopolitan
D. tianshanensis	–	Urceolate	4-spored	20–40 × 12–18	Corticolous	Lecanoric, diploschistesic	Central Asia

Liu-Fu Han (Hebei Normal University, Shijiazhuang 050024, China) for presubmission review. S.Y. Guo was awarded grants by the National Natural Science Foundation of China (31370067, 30770012), and A. Abbas was awarded grants by the Ministry of Science and Technology of China (2012FY111600) and the National Natural Science Foundation of China (31150003). The valuable assistance given by colleagues is gratefully acknowledged.

Literature cited

Abbas A, Wu JN. 1998. Lichens of Xinjiang. Sci-Tec & Hygiene Publishing House of Xinjiang, Urumqi.

Abbas A, Guo SY, Ababaikeli G, Abdulla A, Xahidin H. 2014. *Diploschistes xinjiangensis*, a new saxicolous lichen from northwest China. Mycotaxon 129(2): 465–471. http://dx.doi.org/10.5248/129.465

Fernández-Brime S, Llimona X, Lutzoni F, Gaya E. 2013. Phylogenetic study of *Diploschistes* (lichen-forming *Ascomycota: Ostropales: Graphidaceae*), based on morphological, chemical, and molecular data. Taxon 62(2): 267–280. http://dx.doi.org/10.12705/622.10

Fletcher A, Hawksworth DL, 2009. *Diploschistes*. 378–380, in: CW Smith et al. (eds). The Lichens of Great Britain and Ireland. British Lichen Society, London, pp. 378–380.

Frisch A, Kalb K, Grube M. 2006. Contributions towards a new systematics of the lichen family *Thelotremataceae*. Bibliotheca Lichenologica 92. 556 p. http://dx.doi.org/10.1017/s0024282906219066

Guderley R, Lumbsch HT, 1996. The lichen genus *Diploschistes* in South Africa (*Thelotremataceae*). Mycotaxon 58: 269–292.

Guo SY. 2005. Lichens. 31–82, in: WY Zhuang (ed.). Fungi of northwestern China. Ithaca, New York, Mycotaxon Ltd.

Han LF, Zhang YY, Guo SY. 2013. *Peltigera wulingensis*, a new lichen (*Ascomycota*) from north China. Lichenologist 45(3): 329–336. http://dx.doi.org/10.1017/s0024282912000837

Lumbsch HT. 1988. The identity of *Diploschistes gypsaceus*. Lichenologist 20: 19–24. http://dx.doi.org/10.1017/s0024282988000052

Lumbsch HT. 1989. Die holarktischen Vertreter der Flechtengattung *Diploschistes* (*Thelotremataceae*). Journal of the Hattori Botanical Laboratory 66: 133–196.

Lumbsch HT, Aptroot A. 1993, Studien über die Flechtengattung *Diploschistes* II. Nova Hedwigia 56: 237–239.

Lumbsch HT, Elix JA, 1985. A new species of the lichen genus *Diploschistes* from Australia. Plant Systematics and Evolution 150: 275–279. http://dx.doi.org/10.1007/bf00984201

Lumbsch HT, Elix JA, 1989. Taxonomy of some *Diploschistes* spp. (lichenized ascomycetes, *Thelotremataceae*) containing gyrophoric acid. Plant Systematics and Evolution 167: 195–199. http://dx.doi.org/10.1007/bf00936406

Lumbsch HT, Elix JA, 2003. The lichen genus *Diploschistes* (*Thelotremataceae*) in Australia. Bibliotheca Lichenologica 86: 119–128.

Lumbsch HT, Mangold A. 2007. *Diploschistes elixii* (*Ostropales: Thelotremataceae*), an overlooked terricolous species from Western Australia. Lichenologist 39: 459–462. http://dx.doi.org/10.1017/s0024282907007049

Lumbsch HT, Mayrhofer H, 1990. A new *Diploschistes* species (lichenized ascomycetes, *Thelotremataceae*) from India. Mycotaxon 38: 311–313.

Lumbsch HT, Tehler A, 1998. A cladistic analysis of the genus *Diploschistes* (*Ascomycotina, Thelotremataceae*). Bryologist 101: 398–403. http://dx.doi.org/10.2307/3244178

Mangold A, Elix JA, Lumbsch HT. 2009. *Diploschistes.* Flora of Australia 57(Lichens 5): 227–239.

Martín MP, Winka PK, Llimona X, Lumbsch HT. 2000. Evaluation of morphological variation in the lichen *Diploschistes ocellatus* (*Ascomycota*, *Ostropales*): evidence from nuclear rDNA ITS sequence data. Plant Biology 2(5): 571–578. http://dx.doi.org/10.1055/ s-2000-7471

Martín MP, LaGreca S, Lumbsch HT. 2003. Molecular phylogeny of *Diploschistes* inferred from ITS sequence data. Lichenologist 35: 27–32. http://dx.doi.org/10.1006/lich.2002.0427

Novák Á, Miklós I, Lyngso R, Hein J. 2008. StatAlign: an extendable software package for joint Bayesian estimation of alignments and evolutionary trees. Bioinformatics 24(20): 2403–2404. http://dx.doi.org/10.1093/bioinformatics/btn457

Orange A, James PW, White FJ. 2010. Microchemical methods for the identification of lichens, 2nd edn. British Lichen Society, London.

Pant G, Upreti DK. 1993. The lichen genus *Diploschistes* in India and Nepal. Lichenologist 25: 33–50. http://dx.doi.org/10.1017/s0024282993000040

Pérez-Vargas I, Hernández-Padrón C, Pérez de Paz PL, Elix JA. 2012. A new saxicolous species of *Diploschistes* (*Thelotremataceae*) from the Canary Islands. Lichenologist 44(1): 67–71. http://dx.doi.org/10.1017/s0024282911000612

Tamura K, Peterson D, Peterson N, Stecher G, Nei M, Kumar S. 2011. MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. Molecular Biology and Evolution 28: 2731–2739. http://dx.doi.org/10.1093/molbev/msr121

Wei JC. 1991. An enumeration of lichens in China. International Academic Publishers, Beijing.

White TJ, Bruns TD, Lee SB, Taylor JW, 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis et al. (eds). PCR protocols: a guide to methods and applications. San Diego, Academic Press. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 575–581

http://dx.doi.org/10.5248/131.575

Sporidesmiella lushanensis and *S. jiulianshanensis* spp. nov. and a new record from China

Jian Ma*

College of Agronomy, Jiangxi Agricultural University, Nanchang, 330045, China

*Correspondence to: *majian821210@163.com*

Abstract—Three species of *Sporidesmiella* were collected on dead branches from subtropical forests in southern China. *Sporidesmiella lushanensis* is described as a new species easily distinguished by its verrucose conidiophores and percurrently extending conidiogenous cells that produce clavate to cuneiform 3–5-distoseptate conidia with an obviously thickened dark basal hilum. The new *Sporidesmiella jiulianshanensis* is distinguished from other *Sporidesmiella* species by its ovoid to ellipsoidal smooth conidia with 2 distosepta above and 1 euseptum below. *Sporidesmiella garciniae* var. *brasiliensis* is recorded for the first time from China. These species are described, illustrated, and compared with similar taxa.

Key words—anamorphic fungi, asexual morph, hyphomycetes, taxonomy

Introduction

Most of southern China has a humid subtropical climate conducive to fungal growth, but the anamorphic fungi occurring on plant debris are poorly known (e.g., Zhang et al. 2009, 2010; Ma et al. 2011, 2012, 2014a,b, 2015; Ren et al. 2012; Xia et al. 2013). During our continuing surveys (2012–15) of saprobic microfungi from the forests of southern China, three species referable to the genus *Sporidesmiella* P.M. Kirk (Kirk 1982) were collected on dead branches. Two are new to science while the third represents a new record for China. Specimens are conserved in the Herbarium of the Department of Plant Pathology, Jiangxi Agricultural University, Nanchang, China (HJAUP).

Sporidesmiella lushanensis Jian Ma, **sp. nov.** Fig. 1

MycoBank MB 816246

Differs from *Sporidesmiella sinensis* by its verrucose conidiophores and its wider conidia with more numerous septa.

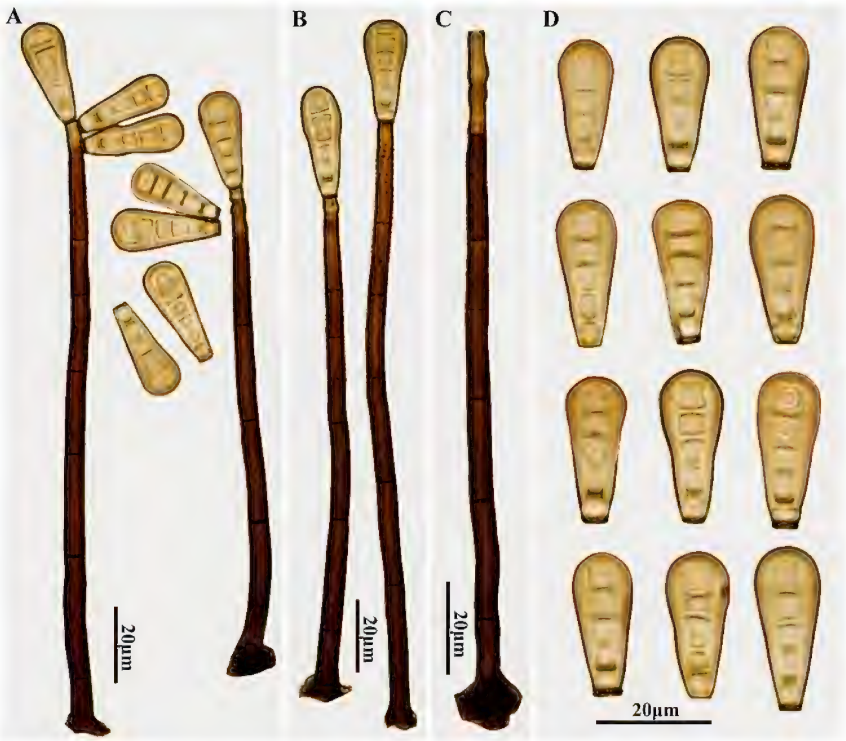


Fig. 1. *Sporidesmiella lushanensis* (holotype, HJAUP M0239). A, B. Conidiophores, conidiogenous cells, and conidia; C. Conidiophore; D. Conidia.

Type: China, Jiangxi Province, Lushan Mountain, on dead branches of an unidentified broadleaf tree, 8 November 2014, J. Ma (**holotype**, HJAUP M0239).

Etymology: refers to the locality where the type specimen was found.

Colonies effuse on the natural substratum, brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores differentiated, single, unbranched, erect, straight or flexuous, septate, verrucose, dark brown to brown, 120–170 μm long, 5–6 μm wide. Conidiogenous cells integrated, terminal, cylindrical, verrucose, brown to pale brown, with several enteroblastic percurrent extensions. Conidial secession schizolytic. Conidia holoblastic, acrogenous, solitary, dry, clavate to cuneiform, pale brown, smooth-walled, 3–5-distoseptate (usually 4), 22–31 μm long, 9.5–12 μm wide in the broadest part, base truncate and 3–4.5 μm wide, apex rounded.

Table 1. Comparisons of setae, conidiophores, and proliferation in *Sporidesmiella lushanensis* and similar species*

Species	Setae	Conidiophores	Conidiogenous cell proliferation
S. claviformis[1]	–	Smooth	Percurrent
S. latispora[2]	–	Smooth	Percurrent
S. lushanensis	–	**Verrucose**	**Percurrent**
S. rosae[3]	–	Verruculose	Percurrent or sympodial
S. setosa[4]	+	Smooth	Percurrent
S. sinensis[3]	–	Smooth	Percurrent

*Data from: [1] Kirk (1982); [2] Wu & Zhuang (2005); [3] Ma et al. (2012); [4] McKemy & Wang (1996)

Comments – *Sporidesmiella lushanensis* resembles *S. claviformis* P.M. Kirk, *S. latispora* W.P. Wu, *S. rosae* Jian Ma & X.G. Zhang, *S. setosa* McKemy & C.J.K. Wang, and *S. sinensis* W.P. Wu in general conidial shape. However, *S. claviformis* can be distinguished by its smooth conidiophores and smaller conidia with fewer septa; *S. latispora* differs by its smooth conidiophores and wider conidia; *S. rosae* differs by its more numerous conidial septa and some sympodial proliferation of conidiogenous cells; *S. setosa* differs by its smooth conidiophores, longer narrower conidia, and conspicuous setae; and *S. sinensis* differs by its smooth conidiophores and narrower conidia with fewer septa (Tables 1, 2).

Table 2. Comparisons of conidia in *Sporidesmiella lushanensis* and similar species*

Species	Shape	Size (μm)	Septa	Basal width (μm)
S. claviformis[1]	Clavate	14–20 × 4.5–9	2	2–2.5
S. latispora[2]	Clavate– obovoid	25–30 × 13.5–17	4	5–6
S. lushanensis	**Clavate– cuneiform**	**22–31 × 9.5–12**	**(3–)4(–5)**	**3–4.5**
S. rosae[3]	Clavate	23–28 × 7–10	(4–)5–6(–7)	2.5–3.5
S. setosa[4]	Cuneiform	30–38 × 7.5–9	4–5	3.5–5
S. sinensis[3]	Clavate– cuneiform	24–26 × 7.5–9	3	4

*Data from: [1] Kirk (1982); [2] Wu & Zhuang (2005); [3] Ma et al. (2012); [4] McKemy & Wang (1996)

Fig. 2. *Sporidesmiella jiulianshanensis* (holotype, HJAUP M0313). A. Conidiophores showing conidiogenous cells and percurrent extensions; B, C. Conidiophores and conidia; D, E. Conidia.

Sporidesmiella jiulianshanensis Jian Ma, **sp. nov.** Fig. 2

MycoBank MB 816247

Differs from all other *Sporidesmiella* species by its ovoid to ellipsoidal conidia with both eusepta and distosepta.

Type: China, Jiangxi Province, Jiulianshan National Nature Reserve, on dead branches of an unidentified broadleaf tree, 3 November 2014, J. Ma (**holotype**, HJAUP M0313).

Etymology: refers to the locality where the type specimen was found.

Colonies effuse on the natural substratum, brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores differentiated, single, unbranched, erect, straight or flexuous, septate, smooth, brown to dark brown, 90–205 × 4.5–6 μm with up to 5 or more percurrent extensions. Conidiogenous cells integrated, terminal, cylindrical, brown to pale brown. Conidial secession schizolytic. Conidia holoblastic, acrogenous, solitary, dry, ovoid to ellipsoidal, brown to pale brown, smooth-walled, 2-distoseptate above and 1-euseptate below, 21–28 μm long, 9.5–10.5 μm wide in the broadest part, apex rounded, base truncate and 2.5–3.5 μm wide.

Comments – *Sporidesmiella cuneiformis* (B. Sutton) P.M. Kirk is the only other species that produces conidia with both eusepta and distosepta. However, *S. cuneiformis* has clavate to cuneiform or obovoid, narrower (6–9.5 µm) conidia with (4–)5 distosepta above and 2 eusepta below (Kirk 1982). *Sporidesmiella jiulianshanensis* produces somewhat similarly shaped conidia as *S. brachysporioides* T.Y. Zhang & W.B. Kendr., which differs by its slightly larger conidia (15–35 × 7.5–13 µm) with 3–4(–5) distosepta (Zhang et al. 1983).

Sporidesmiella garciniae var. ***brasiliensis*** Santa Izabel & Gusmão, Mycosphere 4(2): 158, 2013. Fig. 3

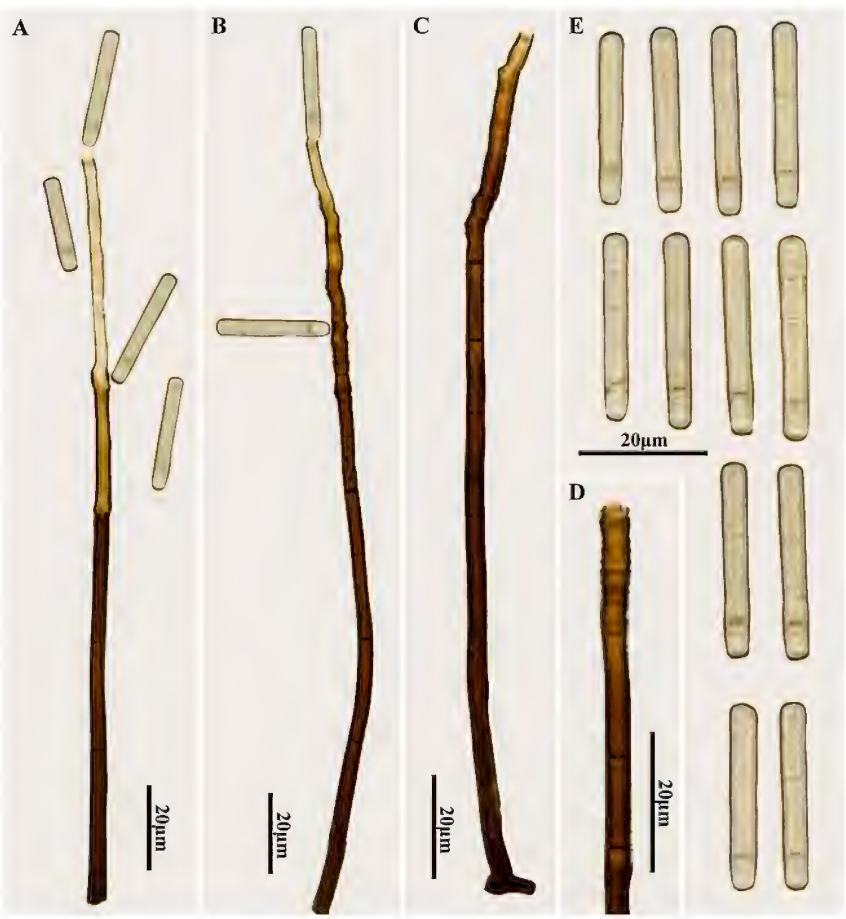


Fig. 3. *Sporidesmiella garciniae* var. *brasiliensis* (HJAUP M0250). A, B. Conidiophores and conidia, with conidiophore apices showing both sympodial and percurrent extensions; C, D. Conidiophores and conidiogenous cells; E. Conidia.

Conidiophores differentiated, single, unbranched, smooth, brown to dark brown, paler at the apex, 140–190 × 3.5–4.5 µm. Conidiogenous cells integrated, terminal, cylindrical, brown to pale brown or subhyaline, with up to 12 or more enteroblastic percurrent extensions, sometimes also with sympodial extensions. Conidial secession schizolytic. Conidia solitary, dry, cylindrical to subcylindrical, smooth, 4-distoseptate, light brown, 22–31 × 3.5–4.5 µm, base truncate and 1.5–2 µm wide, apex rounded.

Specimen examined: **China**, **Jiangxi Province**, Lushan Mountain, on dead branches of an unidentified broadleaf tree, 8 November 2014, J. Ma (HJAUP M0250).

Comments – *Sporidesmiella garciniae* var. *brasiliensis,* which was originally described from Brazil (Santa Izabel et al. 2013), has not been previously recorded in China. It is closely related to *S. garciniae* Matsush. var. *garciniae* in conidial shape but differs in having conidiogenous cells with sympodial extensions. Our collection corresponds well with the original description of the Brazilian variety, except that the holotype had slightly narrower conidia (2.5–4 µm) and shorter conidiophores (32–106 µm; Santa Izabel et al. 2013).

Acknowledgments

The authors express gratitude to Dr. W.B. Kendrick and Dr. Eric H.C. McKenzie for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This project was supported by the National Natural Science Foundation of China (No. 31360011).

Literature cited

Kirk PM. 1982. New or interesting microfungi. VI. *Sporidesmiella* gen. nov. (hyphomycetes). Trans. Br. Mycol. Soc. 79: 479–489. http://dx.doi.org/10.1016/S0007-1536(82)80040-5

Ma J, Wang Y, O'Neill NR, Zhang XG. 2011. A revision of the genus *Lomaantha*, with the description of a new species. Mycologia 103(2): 407–410. http://dx.doi.org/10.3852/10-176

Ma J, Zhang YD, Ma LG, Castañeda-Ruíz RF, Zhang XG. 2012. Three new species of *Sporidesmiella* from southern China. Mycoscience 53: 187–193. http://dx.doi.org/10.1007/s10267-011-0152-1

Ma J, Xia JW, Castañeda-Ruíz RF, Zhang XG. 2014a. *Nakataea setulosa* sp. nov. and *Uberispora formosa* sp. nov. from southern China. Mycol. Progress 13: 753–758. http://dx.doi.org/10.1007/s11557-013-0958-7

Ma J, Zhang XG, Castañeda-Ruíz RF. 2014b. *Ceratosporium hainanensis* and *Solicorynespora obovoidea* spp. nov., and a first record of *Bactrodesmiastrum obscurum* from southern China. Mycotaxon 127: 135–143. http://dx.doi.org/10.5248/127.135

Ma J, Xia JW, Castañeda-Ruíz RF, Zhang XG. 2015. Two new species of *Sporidesmiella* from southern China. Nova Hedwigia 101: 131–137. http://dx.doi.org/10.1127/nova_hedwigia/2015/0254

McKemy JM, Wang CJK. 1996. A new species of *Sporidesmiella* from New York. Mycologia 88: 129–131. http://dx.doi.org/10.2307/3760792

Ren SC, Ma J, Ma LG, Zhang YD, Zhang XG. 2012. *Sativumoides* and *Cladosporiopsis*, two new genera of hyphomycetes from China. Mycol. Progress 11: 443–448. http://dx.doi.org/10.1007/s11557-011-0759-9

Santa Izabel TS, Cruz ACR, Gusmão LFP. 2013. Conidial fungi from the semi-arid Caatinga biome of Brazil. *Ellisembiopsis* gen. nov., new variety of *Sporidesmiella* and some notes of *Sporidesmium* complex. Mycosphere 4(2): 156–163. http://dx.doi.org/10.5943/mycosphere/4/2/1

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Divers. Res. Ser. 15. 351 p.

Xia JW, Ma LG, Ma J, Zhang XG. 2013. Two new species of *Spadicoides* from southern China. Mycotaxon 126: 55–60. http://dx.doi.org/10.5248/126.55

Zhang TY, Kendrick B, Brubacher D. 1983. Annellidic (percurrent) and sympodial proliferation in congeneric hyphomycetes, and a new species of *Sporidesmiella*. Mycotaxon 18: 243–257.

Zhang K, Ma J, Wang Y, Zhang XG. 2009. Three new species of *Piricaudiopsis* from southern China. Mycologia 101(3): 417–422. http://dx.doi.org/10.3852/08-147

Zhang YD, Ma J, Ma LG, Zhang XG. 2010. A new species of *Heteroconium* from Fujian, China. Mycotaxon 114: 315–318. http://dx.doi.org/10.5248/114.315

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 583–588

http://dx.doi.org/10.5248/131.583

Corynesporopsis obclavata and *Stanjehughesia jiangxiensis* spp. nov. from Lushan Mountain, China

Jian Ma*

College of Agronomy, Jiangxi Agricultural University, Nanchang, 330045, China

*Correspondence to: *majian821210@163.com; jxaumj@126.com*

Abstract—Two new species, *Corynesporopsis obclavata* and *Stanjehughesia jiangxiensis*, are described and illustrated from decaying bamboo culms collected in Lushan Mountain, China. *Corynesporopsis obclavata* is characterized by its obclavate, smooth, 5–9-euseptate conidia. *Stanjehughesia jiangxiensis* is easily distinguished by its obclavate to obclavate-rostrate, smooth, 11–14-euseptate conidia.

Key words—anamorphic fungi, bambusicolous fungi, hyphomycetes, taxonomy

Introduction

Bamboos are known to host a number of highly characteristic fungi, of which over 1100 species have been described or recorded (Hyde et al. 2002). Nonetheless, our knowledge of bamboo fungi is incomplete and still at the cataloguing stage (Hyde et al. 2002). To enrich knowledge of bambusicolous fungi, we have been investigating saprobic microfungi occurring on decaying culms of bamboo. Collecting in the forest ecosystems of Lushan Mountain yielded two new hyphomycetes that clearly belong to the genera *Corynesporopsis* P.M. Kirk (Kirk 1981a) and *Stanjehughesia* Subram. (Subramanian 1992). The new species are described, illustrated, and compared with similar taxa. Specimens are conserved in the Herbarium of the Department of Plant Pathology, Jiangxi Agricultural University, Nanchang, China (HJAUP).

Corynesporopsis obclavata Jian Ma, **sp. nov.** Fig. 1

MycoBank MB 816248

Differs from *Corynesporopsis rionensis* by its much longer, obclavate conidia with more numerous eusepta.

Fig. 1. *Corynesporopsis obclavata* (holotype, HJAUP M0204).
A, B. Conidiophores with catenate conidia; C. Conidiophores; D. Conidia.

Type: China, Jiangxi Province, Lushan Mountain, on decaying culms of bamboo, 8 November 2014, J. Ma (**Holotype**, HJAUP M0204).

Etymology: refers to the obclavate conidia.

Colonies on natural substrate effuse, dark brown to black, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth hyphae. Conidiophores differentiated, single, erect, unbranched, straight or flexuous, brown to dark brown, smooth, septate, 100–135 × 5–7 µm. Conidiogenous cells monotretic, integrated, terminal, determinate, sometimes percurrent, cylindrical, brown, smooth, 17–22 × 5–6 µm. Conidial secession schizolytic. Conidia acrogenous, catenate, in chains of two, obclavate, brown, paler toward the apex, smooth, 5–9-euseptate, 27–61 µm long, 6–12 µm diam. in the broadest part, protruding a 2.5–4 µm diam. basal scar.

Comments—*Corynesporopsis,* established by Kirk (1981a) with *Corynespora quercicola* Borowska [≡ *Corynesporopsis quercicola* (Borowska) P.M. Kirk] as type species, is characterized by acrogenous, shortly catenate, euseptate conidia arising from terminal, integrated, monotretic, determinate or rarely percurrently extending conidiogenous cells on differentiated conidiophores. Fifteen species have been described or transferred to the genus based on differences in conidial morphology including shape, size, septation, ornamentation, and pigmentation (Kirk 1981a,b, 1983; Holubová-Jechová & Mercado Sierra 1986; Holubová-Jechová 1987; Morgan-Jones 1988; Sutton 1989; Castañeda-Ruíz & Kendrick 1990; Matsushima 1993; Castañeda-Ruíz et al. 2010; Ma et al. 2012; Xia et al. 2013, 2014; Hernández-Restrepo et al. 2014; Kirschner 2015). Castañeda-Ruíz et al. (2010) provided a key and illustrations to the ten species known at that time; Hernández-Restrepo et al. (2014) provided an expanded key that included two additional species; and Xia et al. (2014) provided a synoptic table of the main morphological features that distinguished 13 accepted species.

Corynesporopsis obclavata is similar only to *C. rionensis* Hol.-Jech., which is clearly differentiated by its fusiform to ellipsoidal, 24–36 × 8–11 µm, 3–4(–5)-euseptate conidia (Holubová-Jechová & Mercado Sierra 1986).

Stanjehughesia jiangxiensis Jian Ma, **sp. nov.** Fig. 2

MycoBank MB 816249

Differs from *Stanjehughesia fasciculata* by its wider, smooth conidia with eusepta but no distosepta; from *S. fusiformis* by its larger conidia with more numerous eusepta; and from *S. polypora* by its shorter conidia with fewer eusepta and without a germ pore in each cell.

Type: China, Jiangxi Province, Lushan Mountain, on decaying culms of bamboo, 8 November 2014, J. Ma (**Holotype**, HJAUP M0274).

Etymology: refers to the province where the type specimen was found.

Colonies on natural substrate effuse, brown. Mycelium superficial, composed of branched, septate, pale brown to brown, smooth-walled hyphae.

Fig. 2. *Stanjehughesia jiangxiensis* (holotype, HJAUP M0274). Conidiogenous cells and conidia.

Conidiophores reduced to conidiogenous cells. Conidiogenous cells monoblastic, determinate, solitary or grouped, cylindrical or ampulliform, brown to dark brown, smooth, 9.5–22 × 3.5–4 μm. Conidial secession schizolytic. Conidia holoblastic, solitary, acrogenous, straight or curved, obclavate to obclavate-rostrate, brown, smooth, 11–14-euseptate, 82–120 μm long, 10–12 μm diam. in the broadest part, tapering to 2.5–3 μm near the apex, 3.5–4 μm diam. at the truncate base.

Comments—Subramanian (1992) established *Stanjehughesia* to accommodate five *Sporidesmium* species, including *S. hormiscioides* Corda [≡ *Stanjehughesia hormiscioides* (Corda) Subram.] as type species. The genus is mainly

characterized by very reduced or absent conidiophores and solitary, euseptate conidia seceding schizolytically from monoblastic, determinate, lageniform or ampulliform, short conidiogenous cells (Subramanian 1992, Wu & Zhuang 2005, Seifert et al. 2011). Sixteen taxa have been included in *Stanjehughesia* (Subramanian 1992, McKenzie 1995, Mena-Portales et al. 2001, Wu & Zhuang 2005, Delgado 2008, Marincowitz et al. 2008, Ma et al. 2011, Almeida et al. 2014). However, only 14 species are currently accepted, of which seven have been recorded from China (Lu et al. 2000, Wu & Zhuang 2005, Ma et al. 2011).

Stanjehughesia jiangxiensis is similar to *S. fasciculata* J. Mena et al., *S. fusiformis* W.P. Wu, and *S. polypora* W.P. Wu in conidial shape. However, *S. fasciculata* differs by its narrower (7–11 µm) verruculose conidia with both eusepta and distosepta and with a broken outer wall at the apical region (Mena-Portales et al. 2001); *S. fusiformis* differs by its much smaller (65–85 × 7–8 µm) 6–8-euseptate conidia with a rostrate subhyaline apex and a wider (4–5 µm) base (Wu & Zhuang 2005); and *S. polypora* differs by its longer (110–165 µm) 15–20-euseptate conidia with a germ pore in each cell (Wu & Zhuang 2005).

Acknowledgments

The authors express gratitude to Dr. W.B. Kendrick and Dr. Eric H.C. McKenzie for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This project was supported by the National Natural Science Foundation of China (No. 31360011).

Literature cited

Almeida DAC, Miller AN, Gusmão LFP. 2014. New species and combinations of conidial fungi from the semi-arid Caatinga biome of Brazil. Nova Hedwigia 98: 431–447. http://dx.doi.org/10.1127/0029-5035/2013/0162

Castañeda-Ruíz RF, Kendrick B. 1990. Conidial fungi from Cuba: II. Univ. Waterloo Biol. Ser. 33. 61 p.

Castañeda-Ruíz RF, Silvera-Simón C, Gené J, Guarro J, Minter DM, Stadler M, Saikawa M. 2010. A new species of *Corynesporopsis* from Portugal. Mycotaxon 114: 407–415. http://dx.doi.org/10.5248/114.407

Delgado G. 2008. South Florida microfungi: a new species of *Stanjehughesia* (hyphomycetes) from Sabal palm. Mycotaxon 103: 229–234.

Hernández-Restrepo M, Gené J, Castañeda-Ruíz RF, Kirk PM, Guarro J. 2014. A new species of *Corynesporopsis* from Spain. Mycotaxon 127: 155–160. http://dx.doi.org/10.5248/127.155

Holubová-Jechová V. 1987. Studies on hyphomycetes from Cuba VI. New and rare species with tretic and phialidic conidiogenous cells. Česká Mykol. 41(2): 107–114.

Holubová-Jechová V, Mercado Sierra A. 1986. Studies on hyphomycetes from Cuba IV. Dematiaceous hyphomycetes from the Province Pinar del Rio. Česká Mykol. 40(3): 142–164.

Hyde KD, Zhou DQ, Dalisay T. 2002. Bambusicolous fungi: a review. Fungal Divers. 9: 1–14.

Kirk PM. 1981a. New or interesting microfungi II. Dematiaceous hyphomycetes from Esher Common, Surrey. Trans. Br. Mycol. Soc. 77(2): 279–297. http://dx.doi.org/10.1016/S0007-1536(81)80031-9

Kirk PM. 1981b. New or interesting microfungi III. A preliminary account of microfungi colonizing *Laurus nobilis* leaf litter. Trans. Br. Mycol. Soc. 77(3): 457–473. http://dx.doi.org/10.1016/S0007-1536(81)80093-9

Kirk PM. 1983. New or interesting microfungi VIII. *Corynesporopsis indica* sp. nov.. Mycotaxon 17: 405–408.

Kirschner R. 2015. Phylogenetic placement of a new species of *Corynesporopsis* from dead acacia wood indicates occurrence of tretic conidiogenesis within *Xylariales.* Phytotaxa 192 (1): 24–34. http://dx.doi.org/10.11646/phytotaxa.192.1.3

Lu BH, Hyde KD, Ho WH, Tsui K., Taylor JE, Wong KM, Yanna, Zhou DQ. 2000. Checklist of Hong Kong Fungi. Fungal Divers. Res. Ser. 5. 207 p.

Ma J, Ma LG, Zhang YD, Zhang XG. 2011. Three new hyphomycetes from southern China. Mycotaxon 117: 247–253. http://dx.doi.org/10.5248/117.247

Ma J, Ma LG, Zhang YD, Castañeda-Ruíz RF, Zhang XG. 2012. New species and record of *Corynesporopsis* and *Hemicorynespora* from southern China. Nova Hedwigia 95: 233–241. http://dx.doi.org/10.1127/0029-5035/2012/0030

Marincowitz S, Crous PW, Groenewald JZ, Wingfield MJ. 2008. Microfungi occurring on the *Proteaceae* in the fynbos. CBS Biodivers. Ser. 7. 166 p.

Matsushima T. 1993. Matsushima Mycological Memoirs No. 7. Published by the author, Kobe, Japan.

McKenzie EHC. 1995. Dematiaceous hyphomycetes on *Pandanaceae*. 5. *Sporidesmium* sensu lato. Mycotaxon 56: 9–29.

Mena-Portales J, Delgado-Rodríguez G, Mercado-Sierra A, Gené J, Guarro J, Iacona V. 2001. New or interesting hyphomycetes from the Biosphere Reserve of Sierra del Rosario, Cuba. Mycologia 93: 751–757. http://dx.doi.org/10.2307/3761830

Morgan-Jones G. 1988. Notes on hyphomycetes. LVII. *Corynespora biseptata*, reclassified in *Corynesporopsis*. Mycotaxon 31(2): 511–515.

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Subramanian CV. 1992. A reassessment of *Sporidesmium* (hyphomycetes) and some related taxa. Proc. Indian natn. Sci. Acad. B 58: 179–190.

Sutton BC. 1989. Notes on deuteromycetes. II. Sydowia 41: 330–343.

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Divers. Res. Ser. 15. 351 p.

Xia JW, Ma LG, Ma YR, Castañeda-Ruíz RF, Zhang XG. 2013. *Corynesporopsis curvularioides* sp. nov. and new records of microfungi from southern China. Cryptogamie, Mycol. 34(3): 281–288. http://dx.doi.org/10.7872/crym.v34.iss3.2013.281

Xia JW, Ma YR, Zhang XG. 2014. New species of *Corynesporopsis* and *Lylea* from China. Sydowia 66(2): 241–248. http://dx.doi.org/10.12905/0380.sydowia66(2)2014-0241

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp.589–596

http://dx.doi.org/10.5248/131.589

New records of *Rhizocarpon* from Hengduan Mountains, China

Wei-Cheng Wang[1], Zhao-Jie Ren[2], Lu-Lu Zhang[3], & Zun-Tian Zhao[3] *

[1]*Key Laboratory of Systematic Mycology and Lichenology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, China*

[2]*Natural Department, Shandong Museum, Jinan 250014, China*

[3]*College of Life Sciences, Shandong Normal University, Jinan 250014, China*

* Correspondence to: *ztzhao@sohu.com*

Abstract—Four species of lichen-forming fungi from Hengduan Mountains are reported new to Asia—*Rhizocarpon effiguratum*, *R. intersitum*, *R. subgeminatum*, and *R. umbilicatum*. These species are described and illustrated in detail and comments on their ecology and distribution ranges are provided.

Key words—*Rhizocarpaceae*, Asia, taxonomy

Introduction

The Hengduan Mountains is a large mountainous region in southwest China (22°–32°N 97°–103°E) and occupies parts of Sichuan, Xizang, and Yunnan Provinces. It consists of several mountain ranges, most of which run roughly north to south, and elevations span 4000–6000 m. Most mountain peaks are permanently covered with snow. Three great rivers of China, the Yangtze, Mekong, and Salween, run in deep parallel valleys separated by mountain ranges. Vast stretches of stones that serve as substrates for various lichens are common in this montane region (Fig. 1).

The Hengduan Mountains were chosen for study because of their rich lichen flora. There is a surprising lack of published information concerning the microlichens of this area. *Rhizocarpon* is a particularly under-studied genus, with only a few species previously recorded: *R. alpicola*, *R. geographicum*, *R. lavatum*, *R. rubescens*, and *R. sinense* (Wang et al. 2015, Zahlbruckner 1930, Zhao et al. 2013). Here we report four additional *Rhizocarpon* species

Fig. 1. The ecotope of Mt. Zheduo, located in Kangding Co., showing the typically rocky landscape in the Hengduan Mountains.

(*R. effiguratum*, *R. intersitum*, *R. subgeminatum*, *R. umbilicatum*) collected in the Hengduan Mountains as new to China as well as to Asia.

Materials & methods

Observations are based on material collected by the authors from Hengduan Mountains in 2015 and preserved in the herbarium of Shandong Normal University, Jinan, China (SDNU), and specimens held in the lichen herbarium of Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China (KUN-L). Morphological and anatomical characters were examined under an Olympus SZ stereomicroscope and an Olympus CX21 polarizing microscope. Both thallus and medulla were tested with K (10% aqueous solution of potassium hydroxide), C (saturated solution of aqueous sodium hypochlorite), I (10% aqueous solution of aqueous potassium iodide), and P (saturated solution of *p*-phenylenediamine in 95% ethyl alcohol) for identification. The lichen substances were identified using standardized thin layer chromatography techniques (TLC) with system C (Orange et al. 2010). Lichen photographs were taken with an Olympus DP72 camera attached to the Olympus SZX16 and BX61 microscopes.

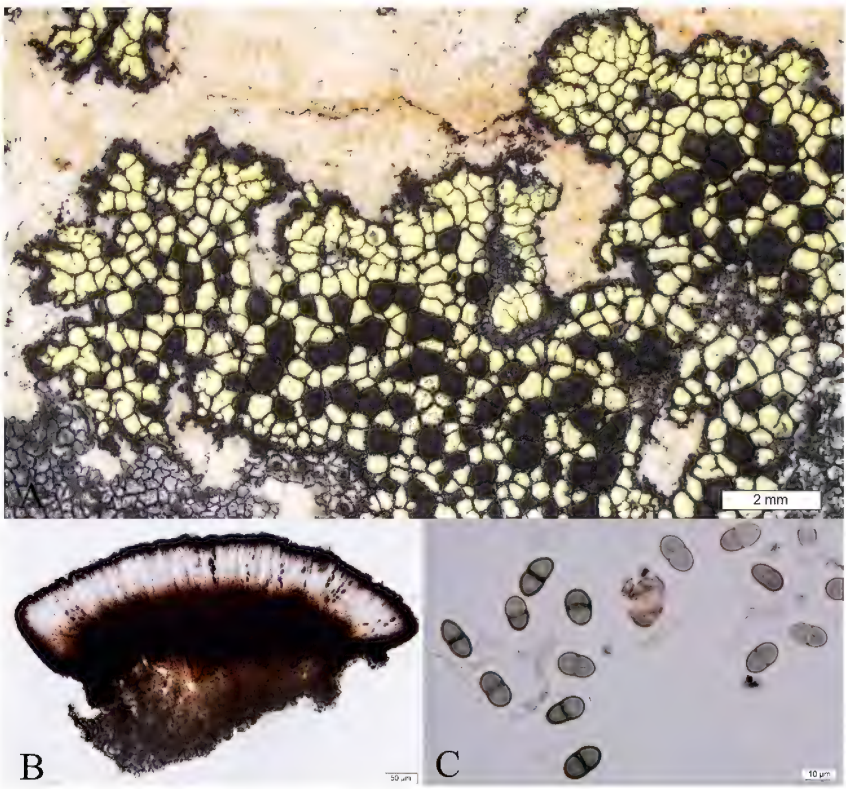


Fig. 2. *Rhizocarpon effiguratum* (SDNU Wang 20150590). A: habitus, distinct black prothallus along the margin of the thallus; B: apothecium section with brown-black epihymenium and poorly developed exciple; C: 1-septate, brown, halonate ascospores. Scale bars: A = 2 mm; B = 50 µm; C = 10 µm.

Taxonomic descriptions

Rhizocarpon effiguratum (Anzi) Th. Fr., Lich. Scand. 1(2): 613 (1874) Fig. 2

Saxicolous. Thallus bright yellow, areolate, ≤3.0 cm diam; medulla I+ violet; prothallus well developed, black, visible between the areolae and along the margin; areoles convex, matt, contiguous, round, 0.2–0.5(–0.8) mm diam. Apothecia 0.25–0.8 mm diam between the areolae, black, epruinose, angular, flat to convex, scabrid, margin persistent; exciple poorly developed; epihymenium green-black or brown-black, hymenium colorless. Asci 8-spored, *Rhizocarpon*-type; ascospores ellipsoid, 1-septate, dark green or brown, paler when young, halonate, 12–15 × 5–6 µm (n = 120).

Chemistry—Medulla K–, C–, P+ yellow; rhizocarpic and psoromic acids detected by TLC.

Specimens examined: **China. Xizang**, Chayu Co., Demula col, 29°19.15′N 97°01.75′E, 4794 m a.s.l., on siliceous rock, 23 Sep. 2014, Li S. Wang et al. 14-46628 (KUN-L); Zuogong Co., Xinde vil., 29°43.57′N 98°04.80′E, 4730 m a.s.l., on siliceous rock, 16 Sep. 2014, Li S. Wang et al. 14-45653, 14-45661 (KUN-L); Mt. Dongda, 5200 m a.s.l., on siliceous rock, 20 Aug. 2004, Li S. Wang 04-25614 (KUN-L); along the road from Mangkang to Zuogong, 4742 m a.s.l., on siliceous rock, 15 Sep. 2014, Li S. Wang et al. 14-45562, 14-45574 (KUN-L); Mangkang Co., Dogdala col, 29°05.48′N 98°36.94′E, 4930 m a.s.l., 17 Aug. 2007, Li S. Wang et al. 07-27990 (KUN-L). **Sichuan**: Ganzi City, Shiqu Co., Luoxv vil., Zebuka col, 4900 m a.s.l., on siliceous rock, 9 Sep. 2009, Li S. Wang 09-30462 (KUN-L); Litang Co., Mt. Haizishan, 29°41′32.79″N, 100°23′20.18″E, 4600 m a.s.l., on siliceous rock, 17 Oct. 2015, Wei C. Wang 20150591, 20150589, 20150593, 20150598, 20150599, 20150600 (SDNU); Litang Co., Mt. Tu'ershan, 29°31′00″N 100°16′11″E, 4896 m a.s.l., on siliceous rock, 17 Oct. 2015, Wei C. Wang 20150590, 20150592, 20150594, 20150595, 20150596, 20150597, 20150603, 20150604 (SDNU).

Distribution—*Rhizocarpon effiguratum* has been previously reported from Europe and North America (Anderson 1965, Timdal & Holtan-Hartwig 1988, Nimis 1993, Llimona & Hladun 2001). New to Asia.

Comments—*Rhizocarpon effiguratum* is a small lichen found in China on high mountains above 4000 m a.s.l. It is characterized by its yellow thallus with distinct black prothallus, I+ violet medulla, angular black apothecia, small brown 1-septate ascospores, and the presence of psoromic acid. *Rhizocarpon pusillum* Runemark and *R. parvum* Runemark are similar to *R. effiguratum* with small, pigmented, 1-septate ascospores, but both are lichenicolous and have a much smaller thallus (≤1 cm diam). *Rhizocarpon superficiale* (Schaer.) Malme, which also resembles *R. effiguratum,* is distinguished by its larger (≥6 cm diam) thallus, and different lichen substances: *R. superficiale* contains rhizocarpic, stictic, and hypostictic acids whereas *R. effiguratum* has rhizocarpic and psoromic acids. *Rhizocarpon alpicola* (Wahlenb.) Rabh. and *R. eupetraeoides* (Nyl.) Blomb. & Forssell have longer (≥18 μm) ascospores; Zahlbruckner (1930) reported the only known Chinese occurrence of *R. alpicola* from Yunnan Province. *Rhizocarpon norvegicum* Räsänen, another species similar to *R. effiguratum*, also produces brown 1-septate ascospores and an I+ violet medulla, but differs in its scattered thallus; it is known from Europe and North America (Thomson 1997).

Rhizocarpon intersitum Arnold, Verh. Zool.-Bot. Ges. Wien 27: 554 (1877) Fig. 3

Saxicolous. Thallus areolate, 2–3 cm diam; medulla I–; prothallus distinct, black; areoles dark grey, slightly to strongly convex. Apothecia black, epruinose, between the areoles, closely attached with areoles, up to 0.2–1.0 mm diam, flat to convex, margin present; exciple poorly developed, epihymenium

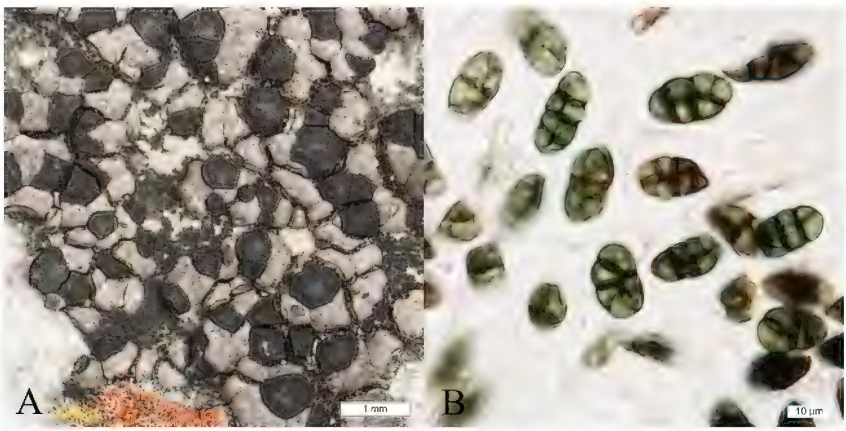


Fig. 3. *Rhizocarpon intersitum* (SDNU Wang 20150601). A: habitus; B: submuriform green halonate ascospores. Scale bars: A = 1 mm; B = 10 µm.

olive-green, K–; hymenium hyaline, upper part with green tinge, thick, ≥100 µm tall. Asci 8-spored; ascospores ellipsoid, submuriform, with 4–7 cells in optical view, dark green, halonate, 20–25 × 12 µm (n = 120).

Chemistry—Medulla K –, C –, P –. No lichen substances detected by TLC.

Specimens examined: **China. Sichuan**, Xiangcheng Co., Mt. Daxueshan, 28°34′N 99°49′E, 4650 m a.s.l., on siliceous rock, 12 Sep. 2002, Li S. Wang 02-21488, 02-22354 (KUN-L); Luding Co., Mt. Gongga, Yajiagen, 29°54′36″N 102°00′14″E, 3800 m a.s.l., on siliceous rock, 13 Oct. 2015, Wei C. Wang 20150574 (SDNU). **Yunnan**, Jianchuan Co., Mt. Laojun, 26°38′12″N 99°47′08″E, 4000 m a.s.l., on siliceous rock, 25 Aug. 2015, Wei C. Wang 20150601 (SDNU).

Distribution—*Rhizocarpon intersitum* has been previously reported from North America and Scandinavia (Anderson 1965, Timdal & Holtan-Hartwig 1988). New to Asia.

Comments—*Rhizocarpon intersitum* is characterized by its dark 4–7-celled ascospores, an olive-green epihymenium, a distinct black prothallus, a dark grey thallus, and absence of lichen substances. *Rhizocarpon flavum* C.W. Dodge & G.E. Baker is close to *R. intersitum* but has a whitish or yellow to green-yellow thallus, a dark brown K+ purple epihymenium, and 2–6 ascospores per ascus.

Rhizocarpon subgeminatum Eitner, Jahresber. Schles. Ges. Vaterl. Cult. 88: 42 (1911) Fig. 4

Saxicolous. Thallus crustose, dark grey; medulla I–; prothallus black; areoles 0.2–0.7 mm diam, flat to slightly to convex, angular. Apothecia

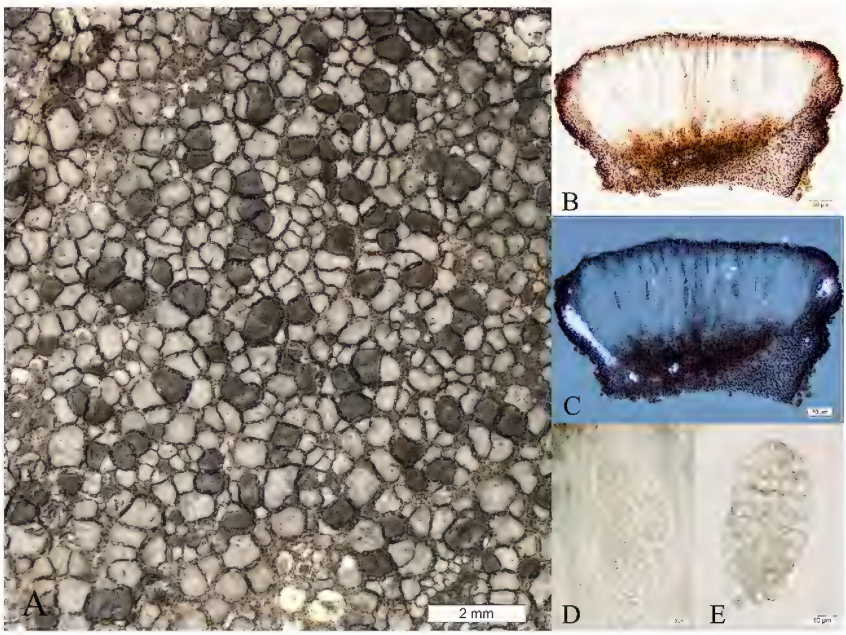


Fig. 4. *Rhizocarpon subgeminatum* (SDNU Wang 20150609). A: habitus; B: apothecium section; C: crystals in exciple (the sample was in water); D: two spores per ascus; E: muriform ascospores. Scale bars: A = 2 mm; B, C = 50 µm; D, E = 10 µm.

black, 0.5–0.8 mm diam, flat, between areoles, scabrid, epruinose; exciple well developed, black at the rim, inner part red-brown, containing crystals, extend to the bottom of hypothecium, ≤100 µm wide, K+ red; epihymenium red-brown, K+ red-purple (Atra-red); hymenium usually with pale green tinge, thick, about 125 µm tall. Asci 2-spored; ascospores ellipsoid, muriform, colorless, halonate, 37–55 × 20–25 µm (n = 30).

Chemistry—Medulla K–, C–, P–. Barbatic acid detected by TLC.

Specimens examined: **China**. **Sichuan**, Luding Co., Mt. Gongga, Yajiagen, 29°54′36″N 102°00′14″E, 3800 m a.s.l., on siliceous rock, 13 Oct. 2015, Wei C. Wang 20150605, 20150606, 20150607, 20150608 (SDNU); Kangding Co., Mt. Zheduo, 30°04′29″N 101°48′12″E, 4200 m a.s.l., on siliceous rock, 15 Oct. 2015, Wei C. Wang 20150609 (SDNU).

Distribution—*Rhizocarpon subgeminatum* has been previously reported from Europe and North America (Timdal & Holtan-Hartwig 1988, Fletcher et al. 2009). New to Asia.

Comments—Ihlen (2004), who reported a chemotype without lichen substances, suggested that one specimen containing barbatic acid was probably

contaminated by fragments of *R. rittokense*. However, the *R. subgeminatum* specimens collected in southwest China all contain barbatic acid detected by TLC, strongly supporting *R. subgeminatum* as having two chemotypes: 1) one with barbatic acid, and 2) one with no lichen substances.

Rhizocarpon umbilicatum (Ramond) Flagey, Mém. Soc. Ému. Doubs, sér. 6, 8: 98 (1894) Fig. 5

Saxicolous. Thallus rimose to areolate, white, pruinose, thick, 0.5–1.0 mm tall; medulla I–; prothallus present only along the margin. Apothecia black, immersed, epruinose, 0.5–1.5 mm diam, disc flat, margin distinct, usually with a white pruina. Exciple poorly developed; epihymenium green-brown K–, containing crystals; hymenium colorless, thin, about 120 μm tall, containing crystals. Asci 8-spored; ascospores ellipsoid, submuriform, with 6–10 cells in optical view, colorless, halonate, 25–30 × 15–18 μm (n = 30).

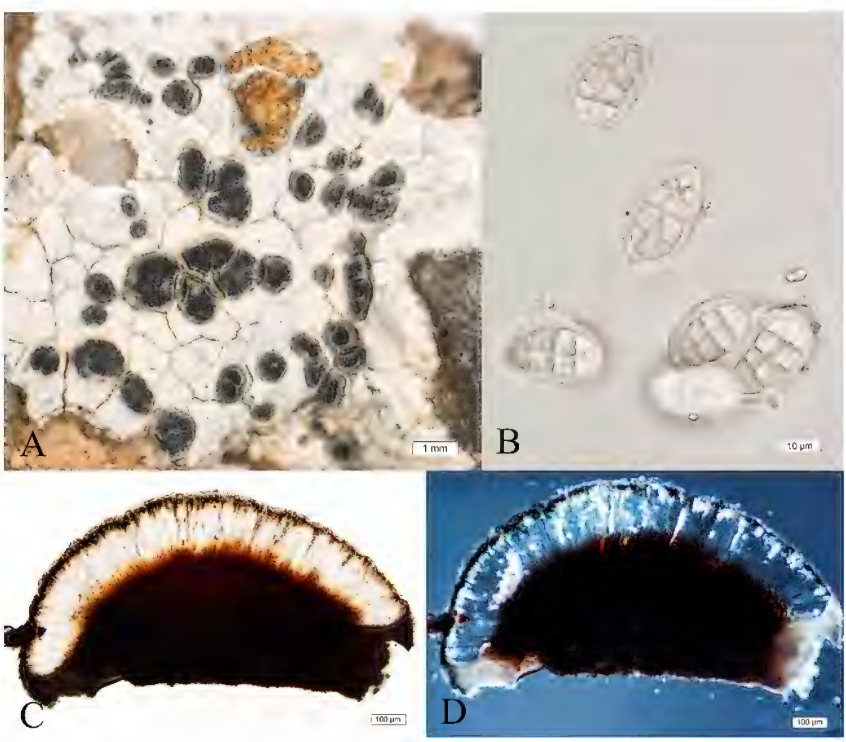


Fig. 5. *Rhizocarpon umbilicatum* (KUN-L Wang 94-15489). A: white thallus and apothecia with pruinose margin; B: submuriform halonate ascospores; C: apothecium section; D: crystals in epihymenium and hymenium (the sample was in water). Scale bars: A = 1 mm; B = 10 μm; C, D = 100 μm.

Chemistry—Medulla K+ yellow, C–, P+ orange. Stictic acid detected by TLC.

Specimens examined: **China. Sichuan**, Yanyuan Co., Mt. Huolu, 4150 m a.s.l., on siliceous rock, 23 Jul. 1983, Li S. Wang 83-1199 (KUN-L); **Yunnan**, Deqin Co., Mt. Baimaxueshan, 4200 m a.s.l., on siliceous rock, 3 Oct. 1994, Li S. Wang 94-15489 (KUN-L).

Distribution—*Rhizocarpon umbilicatum* has been previously reported from Europe, North America, and Australia (Fletcher et al. 2009). New to Asia.

Comments—*Rhizocarpon umbilicatum* is close to *R. petraeum* (Wulfen) A. Massal., which differs by its longer (≥30 μm) ascospores and apothecia lacking a pruinose margin. *Rhizocarpon umbilicatum* is characterized by its white pruinose thallus, apothecia with pruinose margin, submuriform ascospores, and presence of stictic acid.

Acknowledgements

We thank Dr. Martin Westberg (Swedish Museum of Natural History, Stockholm, Sweden) and Dr. S. Pérez-Ortega (Royal Botanical Garden, Madrid, Spain) for presubmission reviews; we also thank E. Timdal (University of Oslo, Norway) for helpful suggestions during our research. This study was supported by the National Natural Science Foundation of China (31170187, 31400015, 31570017), and the Scientific Research Innovation Foundation of Shandong Normal University (SCX1525).

Literature cited

Anderson RA. 1965. Additions to the lichen flora of North America I. Bryologist 68: 54–63.

Fletcher A, Gilbert OL, Clayden S, Fryday AM. 2009. *Rhizocarpon*. 792–808, in: CW Smith et al. (eds). The lichens of Great Britain and Ireland. London: British Lichen Society.

Ihlen PG. 2004. Taxonomy of the non-yellow species of *Rhizocarpon* in the Nordic countries, with hyaline and muriform ascospores. Mycological Research 108: 533–570. http://dx.doi.org/10.1017/S0953756204009803

Llimona X, Hladun NL. 2001. Checklist of the lichens and lichenicolous fungi of the Iberian Peninsula and Balearic Islands. Bocconea 14. 581 p.

Nimis PL. 1993. The lichens of Italy. Museo Regionale di Scienze Naturali, Torino. 897 p.

Orange A, James PW, White FJ. 2010. Microchemical methods for the identification of lichens. 2nd edition. London: British Lichen Society.

Thomson JW. 1997. American Arctic lichens 2. The microlichens. Madison WI, University of Wisconsin Press. 675 p.

Timdal E, Holtan-Hartwig J. 1988. A preliminary key to *Rhizocarpon* in Scandinavia. Graphis Scripta 2: 41–54.

Wang WC, Zhao ZT, Zhang LL. 2015. Four *Rhizocarpon* species new to China. Mycotaxon 130: 883–891. http://dx.doi.org/10.5248/130.883

Zahlbruckner A. 1930. Lichenes. Symbolae Sinicae 3. 254 p.

Zhao ZT, Li C, Zhao X, Zhang LL. 2013. New records of *Rhizocarpon* from China. Mycotaxon 125: 217–226. http://dx.doi.org/10.5248/125.217

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 597–603

http://dx.doi.org/10.5248/131.597

Ellisembia henanensis sp. nov. and two new hyphomycete records from central China

Ji-Wen Xia, Jin-Ye Wang, Chun-Ling Yang, Zhuang Li[*A] & Xiu-Guo Zhang[*B]

Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong, 271018, China

* Correspondence to: [A] *liz552@126.com*, [B] *sdau613@163.com*

Abstract—*Ellisembia henanensis* is described and illustrated from specimens collected on dead branches in Henan Province. The fungus is characterized by distinct single unbranched erect conidiophores, monoblastic conidiogenous cells, and distoseptate fusiform to ellipsoidal conidia. *Lylea tetracoila* and *Menispora glauca* are newly recorded from China.

Key words—conidial fungi, taxonomy

Introduction

During our ongoing survey of microfungi associated with woody debris in subtropical forests of Henan provinces, three species with the morphological characteristics of the genera *Ellisembia* Subram., *Lylea* Morgan-Jones, and *Menispora* Pers. (Subramanian 1992, Morgan-Jones 1975, Persoon 1822) were collected on decaying twigs and dead stems. One of these represents an undescribed species of *Ellisembia*, while the other two specimens represent new species for China. Specimens are deposited in the Herbarium of Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong, China (HSAUP) and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Materials & methods

Samples of woody debris collected were placed in separate zip-lock plastic bags, taken to the laboratory, and then incubated at 27°C for more than 2 weeks in an artificial

climate box in 9 cm diameter plastic Petri dishes containing moistened filter paper. Samples were examined under an Olympus SZ61 dissecting microscope. Fifty mature conidia and 30 conidiophores were mounted in lactophenol, measured at 600× and 1000× magnifications, and photographed with an Olympus BX53 microscope. Adobe Photoshop 7.0 was used to prepare the photographic images; the backgrounds replaced for esthetic reasons.

Taxonomy

Ellisembia henanensis J.W. Xia & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 818289

Differs from *Ellisembia ellipsoidea* by its smaller conidia with fewer distosepta.

Type: China, Henan Province, Jigong Mountain, on dead stems of an unidentified broadleaf tree, 16 Oct. 2015, J.W. Xia (**Holotype**, HSAUP H6697; **isotype**, HMAS 245597).

Etymology: in reference to the type locality.

Colonies on natural substrate effuse, pale brown to brown, hairy. Mycelium partly superficial, partly immersed in the substrate, composed of septate, pale brown, smooth, 2–4 µm wide hyphae. Conidiophores differentiated, single, erect, straight to slightly flexuous, cylindrical, smooth, thick-walled, pale brown to brown, 3–5-septate, 25–50 × 4–5 µm. Conidiogenous cells monoblastic, integrated, terminal, pale brown to brown, 10–15 × 4–5 µm. Conidial secession schizolytic. Conidia solitary, acrogenous, straight or slightly curved, fusiform to ellipsoidal, smooth-walled, pale brown to brown, 4–5-distoseptate, 25–35 × 6–7.5 µm, 1.5–2 µm wide at the truncate base.

Comments—*Ellisembia* was introduced by Subramanian (1992) to accommodate *Sporidesmium*-like species with determinate or irregularly percurrently extending conidiogenous cells that produce distoseptate conidia. Wu & Zhuang (2005) merged *Imicles* Shoemaker & Hambl. (Shoemaker & Hambleton 2001) into *Ellisembia* and expanded the generic concept to include species that produce typically lageniform, ovoid, or doliiform percurrently extending conidiogenous cells.

Ellisembia henanensis is morphologically similar to *E. ellipsoidea* W.P. Wu in conidial shape. However, *E. ellipsoidea* can be easily separated by its larger, 7–8-distoseptate conidia (40–45 × 10–11 µm; Wu & Zhuang 2005).

Lylea tetracoila (Corda) Hol.-Jech., Folia Geobot. Phytotax. 13: 437 (1978). Fig. 2

Colonies on dead wood effuse, dark brown, hairy. Mycelium superficial and immersed, septate, pale brown, smooth-walled hyphae, 1.5–2 µm thick.

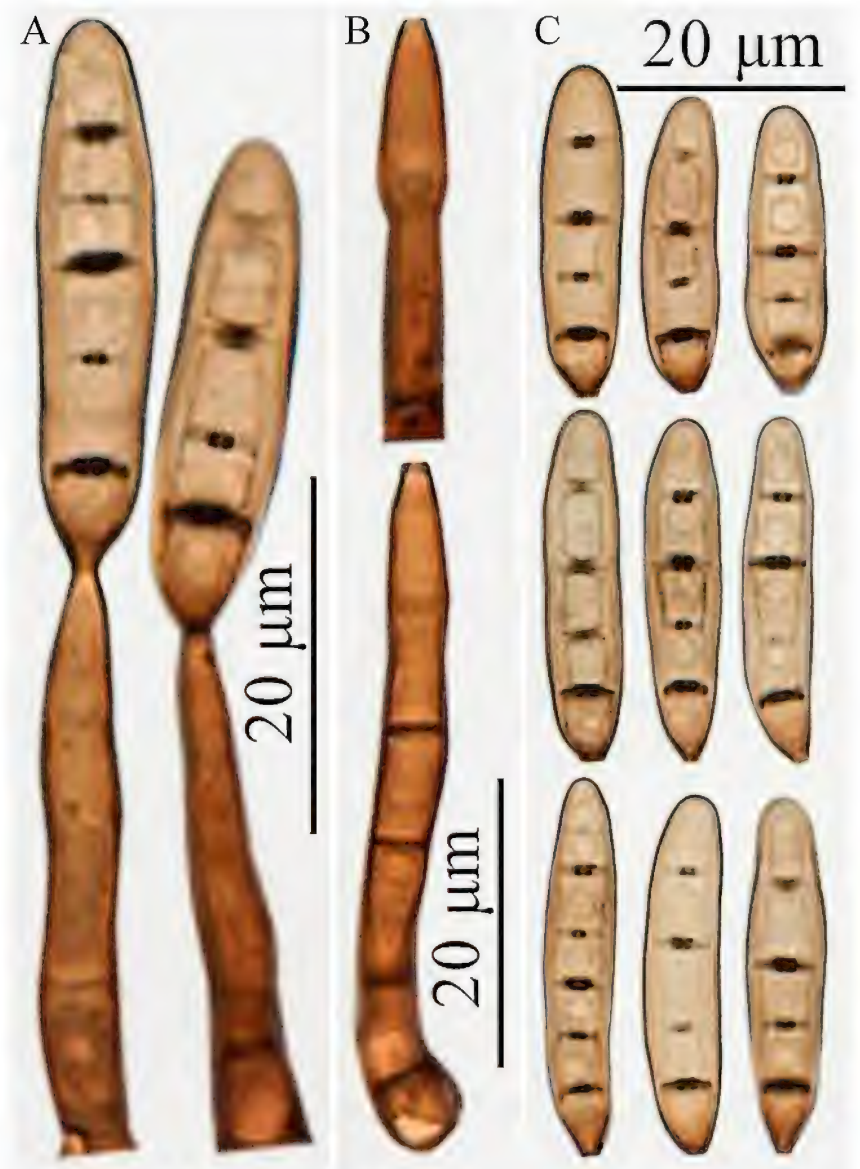


Fig. 1. *Ellisembia henanensis* (ex holotype, HSAUP H6697). A. Conidiophores, conidiogenous cells, and conidia; B. conidiophores and conidiogenous cells; C. conidia.

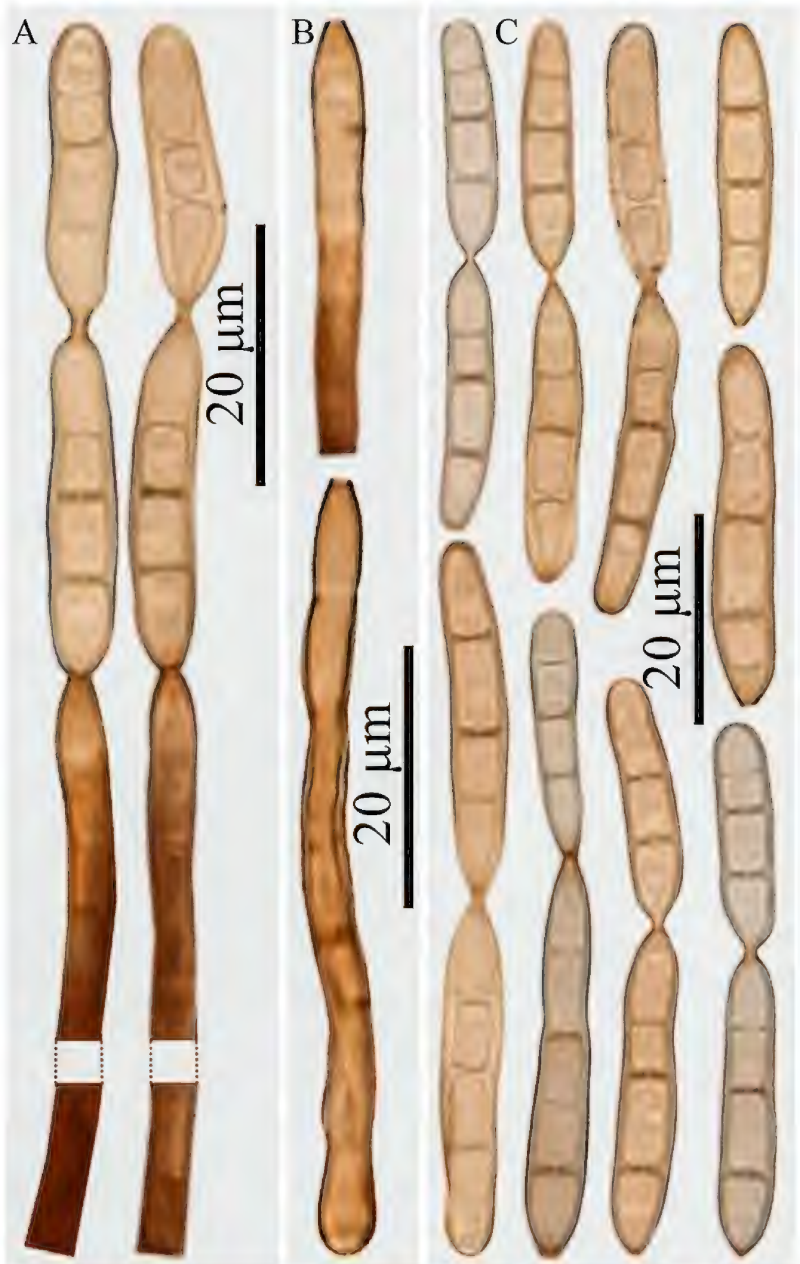


Fig. 2. *Lylea tetracoila* (ex HSAUP H6695). A. Conidiophores, conidiogenous cells, and conidia; B. conidiophores and conidiogenous cells; C. conidia.

Conidiophores macronematous, mononematous, cylindrical, unbranched, 3–6-septate, smooth, pale brown, 30–60 × 3–3.5 µm. Conidiogenous cells monoblastic, integrated, terminal, pale brown, 10–15 × 3–3.5 µm. Conidial secession schizolytic. Conidia holoblastic, solitary, dry, acrogenous, fusiform to cylindrical, 3–4-distoseptate, smooth-walled, pale brown, 20–40 × 4–6 µm.

Specimen examined: **China**, **Henan Province**: Jigong Mountain, on dead stems of unidentified broadleaf tree, 16 Oct. 2015, J.W. Xia (HSAUP H6695).

Comments—*Lylea* was established by Morgan-Jones (1975) with *L. catenulata* Morgan-Jones as the type species. The genus is characterized by the formation of catenate, distoseptate conidia from monoblastic conidiogenous cells. Six species have been described (Morgan-Jones 1975, Holubová-Jechová 1978, Mercado-Sierra et al. 1997, McKenzie 2009, Karandikar & Singh 2010, Xia et al. 2014).

Lylea tetracoila is reported for the first time from China. Our specimen closely matches the description by Holubová-Jechová (1978), which reported conidia measuring (17.5–)20–40(–65) × (3–)4–5.5(–7) µm. We believe they are conspecific.

Menispora glauca Pers., Mycol. Europ. 1: 32 (1822). Fig. 3

Colonies effuse, cushion-like, velvety to cottony, easily separable from the substratum, greyish to blue-grey when sporulating, dark grey-brown when old. Hyphae branched, pale to brown, 2–3 µm wide, septate, superficial and immersed in the substrate. Conidiophores setiform, erect, mostly unbranched, sometimes branched in the lower parts, whip-like twisted toward the apex, dark brown, septate, smooth, 270–450 × 3–4 µm, rounded apex up to 2–3 µm wide. Conidiogenous cells monophialidic, intercalary, discrete, determinate, pale brown, 15–25 × 3–4 µm. Conidia hyaline, cylindrical-allantoid, slightly tapered and rounded ends, curved, 3-septate, 15–20 × 3.5–4.5 µm, with a single, straight or gently curved setula, 4–8.5 µm long at each end.

Specimen examined: **China**, **Henan Province**: Jigong Mountain, on dead stems of an unidentified broadleaf tree, 16 Oct. 2015, J.W. Xia (HSAUP H6699).

Comments—The genus *Menispora*, initially erected by Persoon (1822), was re-described and revised by Hughes & Kendrick (1968) and Holubová-Jechová (1974) to include the following characteristics. Setae, which are either sterile independent structures or hair-like sterile extensions of the setiform conidiophores, are straight (slightly bent to sinuous) or variously coiled and twisted. Conidiogenous cells are terminal and integrated or intercalary and discrete on branched conidiophores. When the conidiophore is setiform, the phialidic conidiogenous cells are (i) lateral and sessile, or (ii) terminal on short

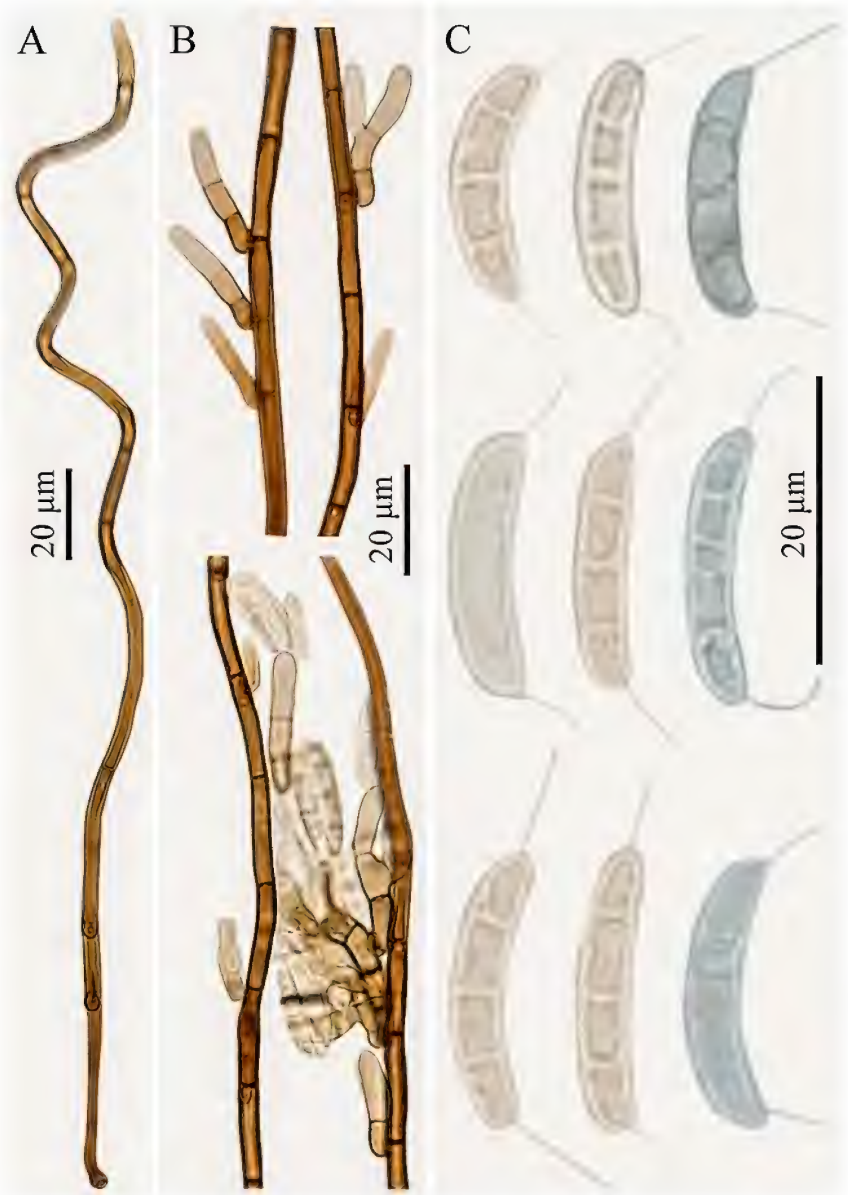


Fig. 3. *Menispora glauca* (ex HSAUP H6699). A. Conidiophore (distal end of sterile extension); B. partial conidiophores, conidiogenous cells, and conidia; C. conidia.

simple stalks, or (iii) lateral and terminal on once- or twice-branched divergent or crowded laterals. The conidiogenous cells are usually slightly or strongly recurved at the apex.

Menispora glauca is reported for the first time from China. Our specimen fits well with the description by Holubová-Jechová (1974), which reported conidia measuring 17–24(–27) × (3.7–)4–5 μm. We conclude that they are conspecific.

Acknowledgments

The authors express gratitude to Dr. De-Wei Li and Dr. Rafael F. Castañeda-Ruiz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 31093440, 31230001, 31493010, 31493011) and the Ministry of Science and Technology of the People's Republic of China (No. 2006FY120100).

Literature cited

Holubová-Jechová V. 1974. Lignicolous hyphomycetes from Czechoslovakia 4. *Menispora*. Folia Geobotanica et Phytotaxonomica 8: 317–336. http://dx.doi.org/10.1007/BF02852830

Holubová-Jechová V. 1978. Lignicolous hyphomycetes from Czechoslovakia 5. *Septonema*, *Hormiactella*, and *Lylea*. Folia Geobotanica et Phytotaxonomica 13: 421–442. http://dx.doi.org/10.1007/BF02851944

Hughes SJ, Kendrick WB. 1968. New Zealand fungi. 12. *Menispora*, *Codinaea*, *Menisporopsis*. New Zealand Journal of Botany 6: 323-375. http://dx.doi.org/10.1080/0028825X.1968.10428818

Karandikar KG, Singh SK. 2010. *Lylea indica*: a new hyphomycetes species from India. Mycotaxon 112: 257–260. http://dx.doi.org/10.5248/112.257

McKenzie EHC. 2009. A new species of *Lylea* (hyphomycetes) on *Rhopalostylis* (*Arecaceae*) in New Zealand. Mycotaxon 109: 39–42. http://dx.doi.org/10.5248/109.39

Mercado-Sierra A, Figueras MJ, Gené J. 1997. New or rare hyphomycetes from Cuba VIII. Species of *Lylea*, *Phaeoisaria*, *Arxiella*, *Graphium*, *Periconia* and *Ramichloridium*. Mycotaxon 63: 369–375.

Morgan-Jones G. 1975. Notes on hyphomycetes. VIII. *Lylea*, a new genus. Mycotaxon 3: 129–132.

Persoon CH. 1822. Mycologia Europaea 1. Erlangen. 356 p.

Shoemaker RA, Hambleton S. 2001. "*Helminthosporium*" *asterinum*, *Polydesmus elegans*, *Imimyces*, and allies. Canadian Journal of Botany 79: 592–599. http://dx.doi.org/10.1139/b01-038

Subramanian CV. 1992. A reassessment of *Sporidesmium* (hyphomycetes) and some related taxa. Proceeding of the Indian National Science Academy, B 58: 179–190.

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Research Series 15. 351 p.

Xia JW, Ma YR, Zhang XG. 2014. New species of *Corynesporopsis* and *Lylea* from China. Sydowia 66(2): 241–248.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 605–611

http://dx.doi.org/10.5248/131.605

Thozetella coronata and *T. ypsiloidea* spp. nov. from the Brazilian Amazon forest

Josiane Santana Monteiro[1], Rafael F. Castañeda-Ruiz[2] & Luis Fernando Pascholati Gusmão[1*]

[1] *Universidade Estadual de Feira de Santana, Avenida Transnordestina, s/n, Novo Horizonte, 44036-900, Feira de Santana, Brazil*

[2] *Instituto de Investigaciones Fundamentales en Agricultura 'Alejandro de Humboldt' (INIFAT), Calle 1 Esq. 2, C.P. 17200, Santiago de Las Vegas, C. Habana, Cuba*

[*] Correspondence to: *lgusmao@uefs.br*

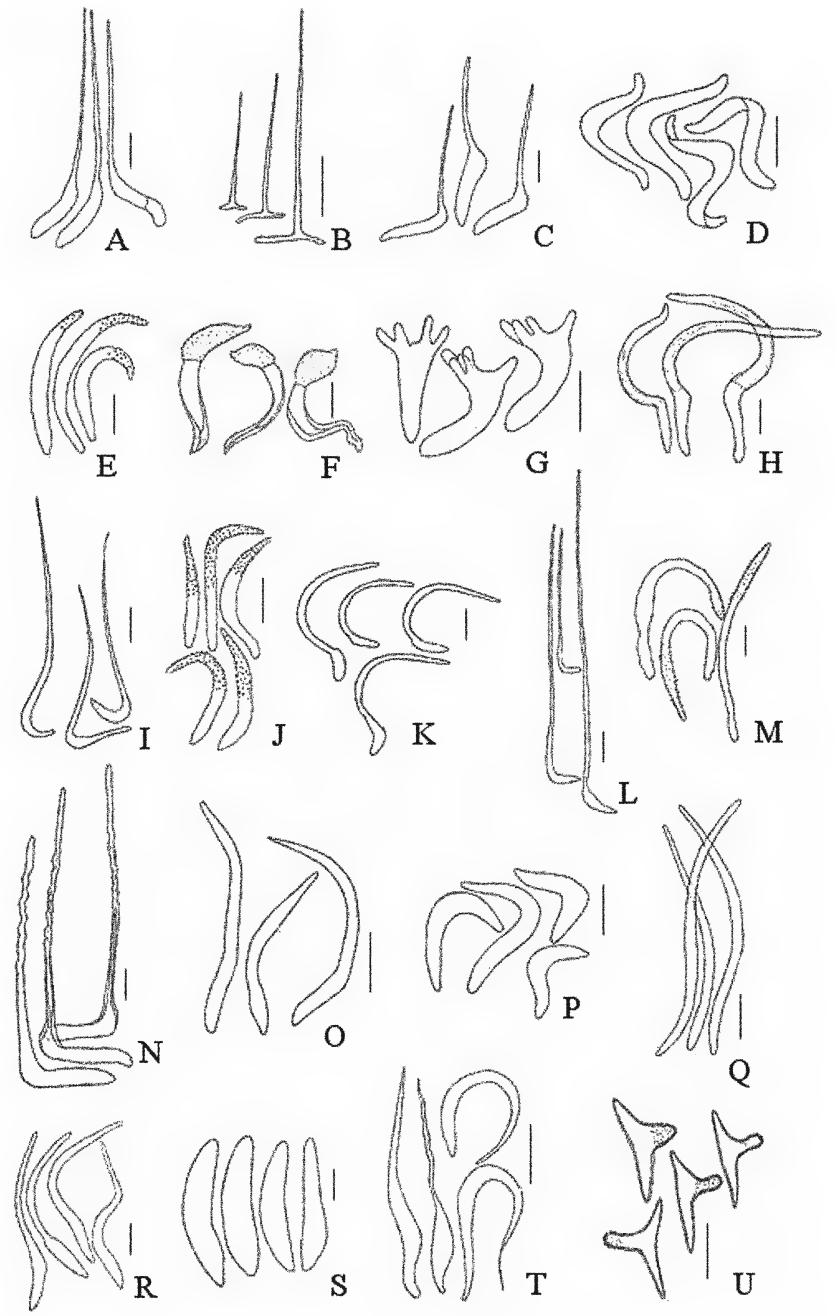
Abstract—Two new species, *Thozetella coronata* and *T. ypsiloidea* collected from submerged leaf litter in the Brazilian Amazon forest, are described and illustrated. *Thozetella coronata* is characterized by the production of clavate coronate hyaline microawns. *Thozetella ypsiloidea* is distinguished by finely verrucose Y-shaped hyaline microawns.

Key words—*Ascomycota*, *Chaetosphaeriaceae*, submerged litter, taxonomy, tropical fungi

Introduction

The Amazon forest is regarded as one of the most important reservoirs of biodiversity in the world (Peres et al. 2010). During a survey of microfungi associated with submerged decaying plant materials from the Brazilian Amazon, several unusual *Thozetella* specimens were found, two of which represent new species and are here described and illustrated.

Thozetella Kuntze is distinguished by the presence of sporodochial, synnematal, or effuse conidiomata, phialidic conidiogenous cells that produce unicellular setulate lunate hyaline conidia, and sterile elements called microawns. Microawns are a diagnostic feature of *Thozetella* (Seifert et al. 2011), and 19 species have been accepted in this genus (Index Fungorum 2016), with microawn morphology (Fig. 1) being the primary basis of species delimitation (Silva & Grandi 2013).


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U

Materials & methods

Samples of submerged decaying plant materials were collecting from streams in the "Área de Proteção Ambiental Ilha do Combu", Pará State, Brazil. Samples were treating according to Castañeda Ruiz et al. (2016) and examined periodically under the stereomicroscope for 30 days. Semi-permanent and permanent microscope slides of fungi were mounted in 100% lactic acid and PVL resin (alcohol polyvinyl, lactic acid, and phenol). The specimens were identified by examination under a compound microscope and microscopic elements were measured at a magnification of ×1000. Photomicrographs were obtained with a Olympus BX51 microscope equipped with bright-field and Nomarski interference optics and a microscopy image acquisition DP25 digital color camera. The specimens are deposited in the Herbarium of Universidade Estadual de Feira de Santana, Bahia, Brazil (HUEFS).

Taxonomy

Thozetella coronata J.S. Monteiro, R.F. Castañeda & Gusmão, **sp. nov.** FIG. 2

MYCOBANK MB 814790

Differs from all other *Thozetella* species by its clavate, coronate microawn.

TYPE: Brazil, Pará State: Área de Proteção Ambiental Ilha do Combu, 1°29′S 48°25′W, on unidentified submerged leaves, 17.I.2011; coll. J.S. Monteiro (**Holotype**: HUEFS 196471).

ETYMOLOGY: Latin, *coronata*, in reference to the crown-like apical projections on the microawns.

COLONIES on the natural substrate cream-coloured. Mycelium immersed; hyphae septate, branched, cylindrical cells, 1.5–2.5 µm diam., smooth-walled, pale brown. CONIDIOMATA sporodochial, superficial, scattered, with a white conidial mass at the apex, 62.5–75 × 175–200 µm diam. CONIDIOPHORES macronematous, septate, cylindrical, smooth, pale brown. CONIDIOGENOUS CELLS monophialidic, integrated, determinate, terminal, cylindrical, smooth, pale brown, 13–15 × 2–3 µm, lacking collarette. CONIDIA lunate, aseptate, smooth, hyaline, 16–20 × 2–3 µm, with a single filiform setula at each end, 6–8 µm long. MICROAWNS mixed and immersed in the conidial mass on the natural substrate, aseptate, clavate, smooth, hyaline, 10–15 × 2–3 µm; apical part swollen, 4–6 µm wide, with 5–6 coronate projections, 1–1.5 µm long; base 1–1.5 µm wide. Teleomorph unknown.

FIG 1. Microawns of *Thozetella* spp.: A. *T. acerosa* (Paulus et al. 2004). B. *T. aculeata* (Silva & Grandi 2011). C. *T. boonjiensis* (Paulus et al. 2004). D. *T. buxifolia* (Allegrucci et al. 2004). E. *T. canadensis* (Nag Raj 1976). F. *T. capitata* (Silva & Grandi 2013). G. *T. coronata* (this work). H. *T. cristata* (Pirozynski & Hodges 1973). I. *T. cubensis* (Castañeda & Arnold 1985). J. *T. effusa* (Sutton & Cole 1983). K. *T. falcata* (Paulus et al. 2004). L. *T. gigantea* (Paulus et al. 2004). M. *T. havanensis* (Castañeda 1984). N. *T. nivea* (Pirozynski & Hodges 1973). O. *T. pinicola* (Jeewon et al. 2009). P. *T. queenslandica* (Paulus et al. 2004). Q. *T. radicata* (Morris 1956, as *Neottiosporella radicata*). R. *T. serrata* (Whitton et al. 2012). S. *T. submersa* (Barbosa et al. 2011). T. *T. tocklaiensis* (Agnihothrudu 1958, as *Thozetellopsis tocklaiensis*).U. *T. ypsiloidea* (this work). Scale bars = 20 µm.

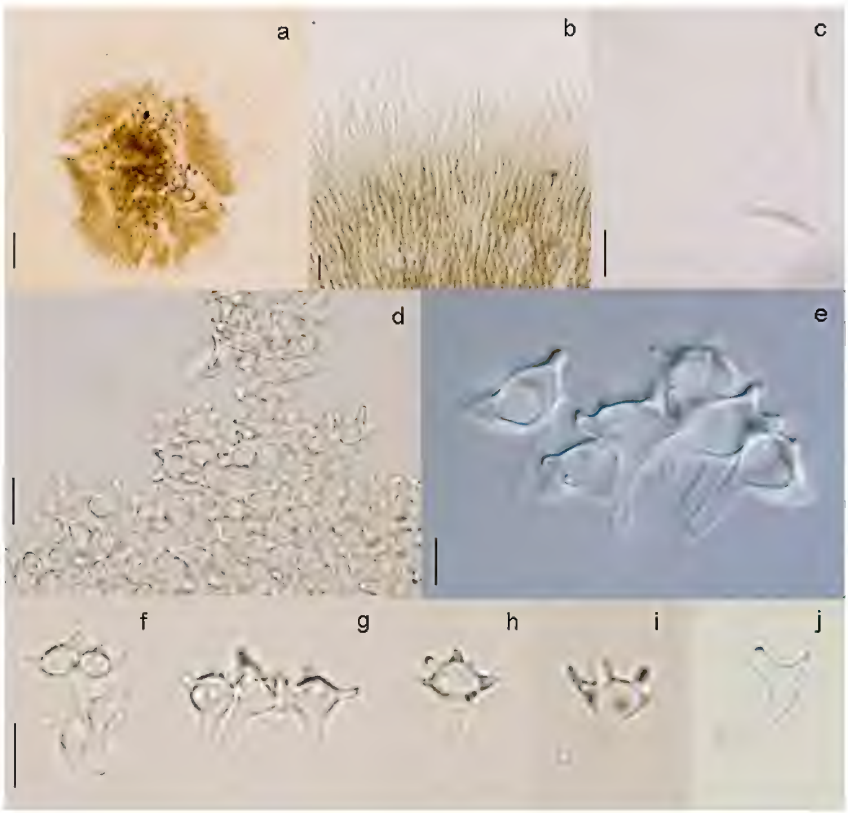


Fig. 2. *Thozetella coronata* (holotype: HUEFS 196471). a. Sporodochial conidioma. b. Conidiogenous cells. c. Conidia with setulae. d. General aspect of microawns. e. Detail of microawns. f–j. Microawns. Scale bars: a = 50 μm; b–j = 10 μm.

Note: All previously described *Thozetella* species differ from *T. coronata* by the absence of clavate, coronate microawns (Barbosa et al. 2011, Silva & Grandi 2013).

Thozetella ypsiloidea J.S. Monteiro, R.F. Castañeda & Gusmão, **sp. nov.** Fig. 3

MycoBank MB 814791

Differs from all other *Thozetella* species by its Y-shaped microawns.

Type: Brazil, Pará State: Área de Proteção Ambiental Ilha do Combu, 1°29′S 48°25′W, on unidentified submerged leaves, 18.X.2011; coll. J.S. Monteiro (**Holotype**: HUEFS 196464).

Etymology: Latin, *ypsiloidea*, in reference to the Y-shaped microawns.

Fig. 3. *Thozetella ypsiloidea* (holotype: HUEFS 196464). a. Sporodochial conidioma. b. General aspect of conidiophores. c. Conidia with setulae. d–i. Microawns. Scale bars: a = 50 µm; b = 20 µm; c–i = 10 µm.

Colonies on the natural substrate cream-coloured. Mycelium immersed; hyphae septate, branched, cylindrical cells, 1.5–2 µm diam., smooth-walled, pale brown. Conidiomata sporodochial, superficial, scattered with a white conidial mass at the apex, 42.5–87.5 × 47.5–150 µm diam. Conidiophores macronematous, septate, cylindrical, smooth, pale brown. Conidiogenous cells monophialidic, integrated, determinate, terminal, cylindrical, smooth, pale brown, 12–25 × 2–3 µm, lacking collarette. Conidia lunate, aseptate, smooth, hyaline, 11–15 × 2–3 µm, with a single filiform setula at each end, 5–8 µm long. Microawns mixed and immersed in mass on the natural substrate,

aseptate, Y-shaped, finely verrucose on arm which has rounded apex and partially verrucose or smooth on the other arm, partially smooth on stipe, hyaline, 12–22 × 8–13 µm; 2–4 µm wide at the base. Teleomorph unknown.

Note: All previously described *Thozetella* species differ from *T. ypsiloidea* by the absence of Y-shaped microawns (Barbosa et al. 2011, Silva & Grandi 2013).

Acknowledgments

The authors express their sincere gratitude to Dr. De-Wei Li and Dr. Xiu-Guo Zhang for their critical review of the manuscript. The authors thank to the National Council for Scientific and Technological Development (CNPq) (Proc. 142014/2011–7) for supporting this study. The first author is grateful to Coordination for the Improvement of Higher Education Personnel (CAPES) for the scholarship. RFCR is grateful to Cuban Ministry of Agriculture and "Programa de Salud Animal y Vegetal", project P131LH003033 Cuban Ministry of Science, Technology and Environment for facilities. We acknowledge the facilities provided by Dr. P.M. Kirk and Dr. V. Robert, through the Index Fungorum and MycoBank websites. Dr. Lorelei Norvell's editorial review and Dr. Shaun Pennycook's nomenclature review are greatly appreciated.

Literature cited

Agnihothrudu V. 1958. Notes on fungi from north-east India. I. A new genus of *Tuberculariaceae*. Mycologia 50(4): 570–579. http://dx.doi.org/10.2307/3756119

Allegrucci N, Cazau MC, Cabello MN, Arambarri A. 2004. *Thozetella buxifolia* sp. nov., a new hyphomycete from Argentina. Mycotaxon 90(2): 275–279.

Barbosa FR, Silva SS, Fiuza PO, Gusmão LFP. 2011. Conidial fungi from the semi-arid Caatinga biome of Brazil. New species and records for *Thozetella*. Mycotaxon 115: 327–334. http://dx.doi.org/10.5248/115.327

Castañeda Ruiz RF. 1984. Nuevos taxones de Deuteromycotina: *Arnoldiella robusta* gen. et sp. nov.; *Roigiella lignicola* gen. et sp. nov.; *Sporidesmium pseudolmediae* sp. nov. y *Thozetella havanensis* sp. nov. Revista del Jardín Botánico Nacional, Universidad de La Habana 5(1): 57–87.

Castañeda Ruiz RF, Arnold GRW. 1985. Deuteromycotina de Cuba. I. Hyphomycetes. Revista del Jardín Botánico Nacional, Universidad de La Habana 6(1): 47–67.

Castañeda Ruiz RF, Heredia G, Gusmão LFP, Li DW. 2016. Fungal diversity of Central and South America. 197–217, in: DW Li (ed.). Biology of Microfungi, Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-29137-6_9

Index Fungorum. 2016. http://www.indexfungorum.org/Names/Names.asp (accessed 22 Apr. 2016).

Jeewon R, Yeung SYQ, Hyde KD. 2009. A novel phylogenetic group within *Thozetella* (*Chaetosphaeriaceae*): a new taxon based on morphology and DNA sequence analyses. Canadian Journal of Microbiology 55(6): 680–687. http://dx.doi.org/10.1139/W08-148

Morris EF. 1956. Tropical fungi imperfecti. Mycologia 48(5): 728–737. http://dx.doi.org/10.2307/3755382

Nag Raj TR. 1976. Miscellaneous microfungi. I. Canadian Journal of Botany 54(12): 1370–1376. http://dx.doi.org/ 10.1139/b76-149

Paulus B, Gadek P, Hyde KD. 2004. Phylogenetic and morphological assessment of five new species of *Thozetella* from an Australian rainforest. Mycologia 96(5): 1074–1087. http://dx.doi.org/10.2307/3762090

Peres, CA, Gardner TA, Barlow J, Zuanon J, Michalski F, Lees AC, Vieira ICG, Moreira FMS, Feeley KJ. 2010. Biodiversity conservation in human-modified Amazonian forest landscapes. Biological Conservation 143: 2314–2327. http://dx.doi.org/10.1016/j.biocon.2010.01.021

Pirozynski KA, Hodges CS Jr. 1973. New hyphomycetes from South Carolina. Canadian Journal of Botany 51(1): 151–173. http://dx.doi.org/10.1139/b73-024

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Silva P, Grandi RAP. 2011. A new species of *Thozetella* from Brazil. Cryptogamie Mycologie 32: 359–363. http://dx.doi.org/10.7872/crym.v32.iss4.2011.359

Silva P, Grandi RAP. 2013. Taxonomic studies of *Thozetella* Kuntze (anamorphic *Chaetosphaeriaceae, Ascomycota*). Nova Hedwigia 97(3–4): 361–399. http://dx.doi.org/10.1127/0029-5035/2013/0121

Sutton BC, Cole GT. 1983. *Thozetella* (*Hyphomycetes*): an exercise in diversity. Transactions of the British Mycological Society 81(1): 97–107. http://dx.doi.org/10.1016/S0007-1536(83)80209-5

Whitton SR, McKenzie EHC, Hyde KD. 2012. Anamorphic fungi associated with *Pandanaceae*. Fungal Diversity Research Series 21: 125–353. http://dx.doi.org/10.1007/978-94-007-4447-9_4

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 613–619

http://dx.doi.org/10.5248/131.613

Long-hidden in Thaxter's treasure trove: *Laboulbenia camerunensis* sp. nov. parasitic on African *Curculionidae*

Tristan W. Wang[1], Danny Haelewaters[2*] & Donald H. Pfister[2]

[1] *Harvard College, 365 Kirkland Mailing Center, Cambridge, Massachusetts 02138, U.S.A.*

[2] *Farlow Reference Library and Herbarium of Cryptogamic Botany, Harvard University, 22 Divinity Avenue, Cambridge, Massachusetts 02138, U.S.A.*

[*] Correspondence to: *dhaelewaters@fas.harvard.edu*

Abstract—A new species, *Laboulbenia camerunensis*, parasitic on *Curculio* sp. from Cameroon, is described from a historical slide prepared by Roland Thaxter. It is the seventh species to be described from the family *Curculionidae* worldwide and the first from the African continent. The species is recognized by the characteristic outer appendage. The latter consists of two superimposed hyaline cells, separated by a black constricted septum, the suprabasal cell giving rise to two branches, the inner of which is simple and hyaline, and the outer tinged with brown. A second blackish constricted septum is found at the base of this outermost branch. Description, illustrations, and comparison to other species are given.

Key words—*Laboulbeniales*, *Laboulbeniomycetes*, insect-associated fungi, taxonomy, weevils

Introduction

The order *Laboulbeniales* (*Fungi*, *Ascomycota*, *Laboulbeniomycetes*) consists of microscopic ectoparasites that develop on the exoskeleton of certain invertebrates. The hosts are primarily beetles but also include millipedes, mites, and a variety of insects (flies, ants, cockroaches, and others). Unlike other multicellular fungi, *Laboulbeniales* exhibit determinate growth, meaning that the fungal body (thallus) develops from a two-celled ascospore through a restricted and regulated number of mitotic divisions to produce an individual with a set number of distinctively arranged cells (Tavares 1985, Santamaría 1998).

Although the earliest observations on these parasites occurred in the 1840s (Rouget 1850), it was not until the research of Roland Thaxter [1858–1932] that the *Laboulbeniales* were studied in depth. In 1890 Thaxter published the first in a series of twenty-one non-illustrated papers in which hundreds of new species were described. His five-volume illustrated monograph, published between 1896 and 1931, forms the basis for all later studies of the group. Since Thaxter died one year after the publication of the fifth volume, a planned sixth volume was never prepared. This was to have been a synthesis of the large genus *Laboulbenia* and "a general review, classification, and host-index" (Thaxter 1931). Although Thaxter left no manuscript for this final volume (Benjamin 1971), the Farlow Reference Library of Cryptogamic Botany archived his sketches and notes on undescribed species, many of which were recently re-examined along with his slide preparations.

Our recent interest in Thaxter's permanent slide collection has resulted in the description of several new species of *Laboulbeniales* on beetle hosts in the families *Carabidae* (*Laboulbenia poplitea* Haelew.), *Chrysomelidae* (*Laboulbenia bilobata* Haelew. & W. Rossi, *L. longipilis* Haelew. & W. Rossi, *L. pfisteri* Haelew. & W. Rossi), *Erotylidae* (*Laboulbenia erotylaridarum* Haelew.), and *Hydrophilidae* (*Zodiomyces rhizophorus* W. Rossi et al.) (Haelewaters & Yaakop 2014, Haelewaters & Rossi 2015, Rossi et al. 2016b). Further examination of the slides revealed yet another undescribed species of *Laboulbenia*, on *Curculio* sp., a member of the family *Curculionidae* (Wang 2014). Although reported by his contemporary Spegazzini (1917) from Argentina and more recently by Sugiyama & Majewski (1987) and Rossi et al. (2015), this is the only material studied by Thaxter that occurs on a member of the *Curculionidae.*

Currently about 2100 species of *Laboulbeniales* have been described. Species descriptions in *Laboulbeniales* are based exclusively on morphological characters, except for two species (*Hesperomyces coleomegillae* W. Rossi & A. Weir, *H. palustris* W. Rossi & A. Weir) whose morphological descriptions are supported by molecular characters (Goldmann et al. 2013). Generating sequences of *Laboulbeniales* has not been easy, although recent endeavors offer hope for advancing molecular phylogenetic research in the group when adequate fresh material is available (Haelewaters et al. 2015).

Although many authors agree that adequate species descriptions require the study of multiple juvenile and mature thalli, quite a few descriptions have been based on only one, two, or very few thalli. In these cases, morphology should be unusual and distinctive enough to make a strong case for describing the species. Examples where limited material has been used for description are *Cantharomyces magellanicus* Thaxt. (3 thalli studied, of which only one was mature, but damaged), *Dimeromyces osellae* W. Rossi (1 female and

1 male thallus), *Laboulbenia arietina* Thaxt. (4 thalli), *L. longipilis* (2 thalli), *Monoicomyces denticulatus* Thaxt. (3 thalli, of which two were mature), and *Peyritschiella xyricola* Thaxt. (1 thallus) (Haelewaters & Rossi 2015; Rossi 2010; Thaxter 1914, 1915, 1931). A more extreme case is *Peyritschiella lampropygi* Thaxt., which was described on the basis of material that was not fully developed (Thaxter 1931). For the description of the genus *Columnomyces* R.K. Benj., only a single mature (and broken) thallus was available among the 19 immature/broken thalli (Benjamin 1955).

One difficulty with our new species is that we did not have multiple adult specimens, but the available material does include one mature thallus in addition to several immature thalli. Nonetheless, because this species is easily distinguished from other *Laboulbenia* species based on the characters of the outer appendage, we describe it here as a new species. Such records help to direct collecting and ultimately inform diversity studies.

Materials & methods

Material was discovered amongst unidentified mounts studied by Roland Thaxter in the permanent slide collection, deposited at the Farlow Herbarium, Harvard University (FH).

Observations and measurements were made using an Olympus BX40 light microscope with Olympus XC50 digital camera and MicroSuite Special Edition software 3.1 (Soft Imaging Solutions GmbH). Line drawings were made using a drawing tube. Illustrations were optimized (using LEVELS and BRIGHTNESS/CONTRAST tools), cropped, and edited in Adobe Photoshop CS Version 8.0 (San Jose, California).

Taxonomy

Laboulbenia camerunensis T.W. Wang & Haelew., **sp. nov.** PLATE 1

MYCOBANK 811237

Differs from all other *Laboulbenia* species on *Curculionidae* by its striking outer appendage.

TYPE: Cameroon, on the abdomen of *Curculio* sp. (family *Curculionidae*, subfamily *Curculioninae*), Jun. 1912, no collector, Thaxter 2360 (**Holotype**, FH 00313482 [slide, in poor condition, partly dried out; 1 mature thallus and 10 thalli in various stages of development]).

ETYMOLOGY: The epithet *camerunensis* is derived from the country where the holotype was collected.

THALLUS hyaline, with the exception of the dark brown outermost branch of the outer appendage; 160 µm long from foot to perithecial tip. CELLS I and II of similar length, up to 3× as long as broad, with subparallel margins; forming an elongated pedestal. CELL III slightly longer than broad, distally widening. CELL IV about as long as cell III or somewhat shorter. CELL V wedge-shaped, almost

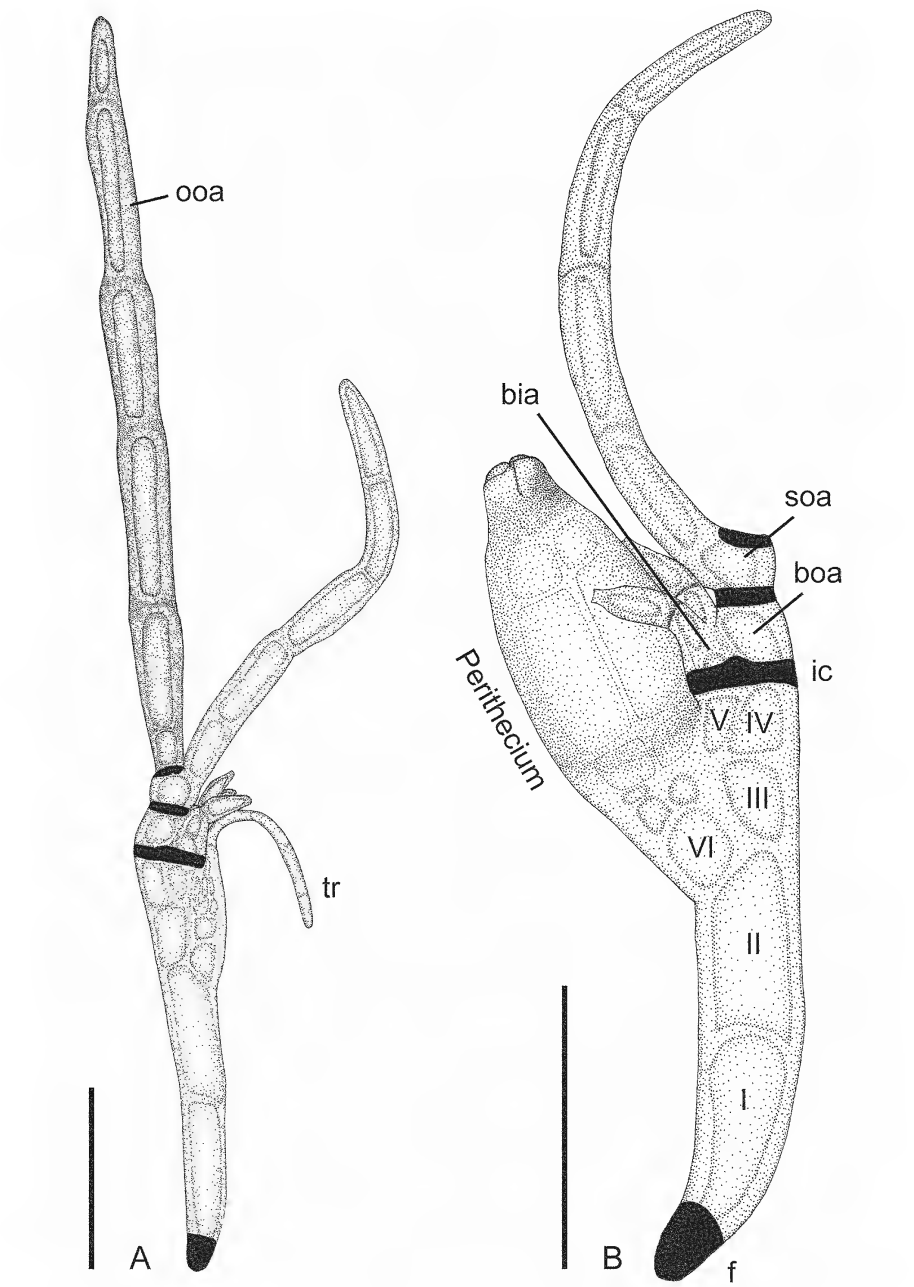
as long as cell IV; septum IV–V is oblique and reaches cell III. Insertion cell black, flattened, not marking an evident constriction on the posterior margin of the thallus. Outer appendage consisting of two superimposed almost hyaline cells separated by a black constricted septum; two simple branches arising from the suprabasal cell, composed of cells much longer than broad; the septum separating the suprabasal cell and the lower cell of the outermost branch, black, often oblique, and the area above tinged with dark brown. Inner appendage with very small basal cell, giving rise to 2–3 small cells, longer than broad, each carrying one flask-shaped antheridium, separated by a thin, dark-brown septum. Cell VI quadrangular with subequal width and length. Perithecium fusiform, largely free, 65 × 30 μm; strongly tapered at the tip, ending in four hyaline and rounded lips, two of which carry small papillae; preostiolar spots reduced to only the posterior one, which consists of a shaded area occupying the posterior lip.

Discussion

We think it is safe to assume that the host genus is correctly identified as *Curculio* Linnaeus 1758, according to current taxonomical concepts. The superfamily *Curculionoidea* (*Coleoptera*) comprises over 60,000 species of weevils, most of which represent the *Curculionidae* (true weevils). The phylogenetic classification of this family is complex, leading to recent debate (Jordal et al. 2014). However, the taxonomy of the *Curculionini* tribe in Africa has remained almost unchanged since Thaxter's work (Löbl & Smetana 2013, Caldara et al. 2014).

Six *Laboulbenia* species were previously described from *Curculionidae: L. curculionidicola* K. Sugiy. & T. Majewski from Peru; *L. dichroma* W. Rossi et al. on *Geraeus* sp. from Ecuador; *L. elephantina* W. Rossi et al. on *Udeus* sp. from Ecuador; *L. hyemalis* Speg. on *Anthonomus* sp. from Argentina; *L. inopinata* W. Rossi et al. on *Lechriops* spp. and *Macrocopturus* spp. from Ecuador; and *L. microcarpa* W. Rossi et al. on *Sicoderus* sp. and *Lancearius esau* from Ecuador (Spegazzini 1917, Sugiyama & Majewski 1987, Rossi et al. 2015). *Laboulbenia camerunensis* can be easily distinguished from these species by its characteristic

Plate 1. *Laboulbenia camerunensis* (holotype, FH 00313482). A. Juvenile thallus, with trichogyne (*tr*), an external thin appendage-like outgrowth of the young perithecium through which fertilization occurs. B. Mature thallus, with the outermost branch of the outer appendage broken off above the suprabasal cell (*soa*). Scale bars = 50 μm. Labeled are: the foot (*f*) with which the thallus attaches to the host's integument; cells I, II, III, IV, and V of the receptacle; the insertion cell (*ic*); the basal cell (*boa*), and suprabasal cell (*soa*) of the outer appendage, as well as its outermost branch (*ooa*) [only in A]; the very small basal cell of the inner appendage (*bia*), which carries 2 [in B] or 3 [in A] cells each supporting a single antheridium; and cell VI, carrying the perithecium (including basal cells).


ooa
tr
A
bia
soa
boa
ic
Perithecium
V
IV
III
VI
II
I
B
f

outer appendage structure, in particular the two dark septa at the base and the outermost branch tinged with dark brown above its lower cell.

Laboulbenia curculionidicola is additionally distinguished from *L. camerunensis* by cell II being twice as long as cell I, cell III usually splitting into two, cell V located in the upper inner corner of cell IV, and the outer appendage comprising a simple branch. *Laboulbenia hyemalis* is further distinguished by its outer appendage consisting of a single main axis that is blackened only at the posterior margin and its perithecial tip distinctly curved toward the anterior side. *Laboulbenia dichroma*, *L. elephantina*, and *L. microcarpa*, among other differences, have a simple, unbranched outer appendage. The final species, *L. inopinata*, differs greatly from all other species on *Curculionidae* in its undivided androstichum (= cells III + IV + V) and very simple appendage structure. The undivided androstichum is actually typical for species of *Laboulbenia* on *Chrysomelidae* (Rossi et al. 2016a).

The outer appendage of *L. camerunensis,* highly distinctive in *Laboulbenia*, superficially resembles *L. pfisteri*, which, however, differs in many other characteristics: (i) cell V does not reach cell III, (ii) the outer appendage has an additional third branch borne on the inner angle of the basal cell, and (iii) the perithecium is noticeably enlarged in its upper portion (Haelewaters & Rossi 2015).

Roland Thaxter's original sketch of this species, obtained from the archives of the Farlow Reference Library of Cryptogamic Botany, was published in Wang (2014: 3).

Acknowledgments

We wish to thank Lisa Decesare, Head of Archives and Public Services at the Botany Libraries, Harvard University, for her efforts to access Roland Thaxter's unfinished drawings in the archives of the Farlow Reference Library. We also thank Kanchi N. Ghandhi for nomenclatural advice, Meredith Blackwell and Walter P. Pfliegler for reviewing the manuscript, and Shaun R. Pennycook for additional edits and suggestions.

Literature cited

Benjamin RK. 1955. New genera of *Laboulbeniales*. El Aliso 3(2): 183–197.

Benjamin RK. 1971. Introduction and supplement to Roland Thaxter's Contribution towards a Monograph of the *Laboulbeniaceae*. Bibliotheca Mycologica 30: 1–155.

Caldara R, Franz NM, Oberprieler RG. 2014. *Curculionidae* Latreille, 1802. 589–628, in: RAB Leschen, RG Beutel (eds). Handbook of Zoology, Coleoptera Vol. 3: Morphology and Systematics (Phytophaga). Berlin, Walter De Gruyter.

Goldmann L, Weir A, Rossi W. 2013. Molecular analysis reveals two new dimorphic species of *Hesperomyces* (*Ascomycota*, *Laboulbeniomycetes*) parasitic on the ladybird *Coleomegilla maculata* (*Coleoptera*, *Coccinellidae*). Fungal Biology 117(11–12): 807–813. http://dx.doi.org/10.1016/j.funbio.2013.10.004

Haelewaters D, Rossi W. 2015. Three new species of *Laboulbenia* from Roland Thaxter's backlog of slides and a brief review of *Laboulbeniales* associated with *Chrysomelidae*. Mycologia 107(1): 142–148. http://dx.doi.org/10.3852/14-022

Haelewaters D, Yaakop S. 2014. New and interesting *Laboulbeniales* from southern and southeastern Asia. Mycotaxon 129(2): 439–454. http://dx.doi.org/10.5248/129.439

Haelewaters D, Gorczak M, Pfliegler WP, Tartally A, Tischer M, Wrzosek M, Pfister DH. 2015. Bringing *Laboulbeniales* into the 21st century: enhanced techniques for extraction and PCR amplification of DNA from minute ectoparasitic fungi. IMA Fungus 6(2): 363–372. http://dx.doi.org/10.5598/imafungus.2015.06.02.08

Jordal BH, Smith SM, Cognato AI. 2014. Classification of weevils as a data-driven science: leaving opinion behind. ZooKeys 439: 1–18. http://dx.doi.org/10.3897/zookeys.439.8391

Löbl I, Smetana A. 2013. Catalogue of Palaearctic *Coleoptera*, Volume 8: *Curculionoidea* II. Leiden, Brill.

Rouget A. 1850. Notice sur une production parasite observée sur le *Brachinus crepitans*. Annales de la Société Entomologique de France 8: 21–24.

Rossi W. 2010. New *Laboulbeniales* (*Ascomycota*) parasitic on *Staphylinidae* from Ecuador. Mycological Progress 9(3): 407–415. http://dx.doi.org/10.1007/s11557-009-0650-0

Rossi W, Torres JA, Bernardi M. 2015. New *Laboulbeniales* parasitic on weevils from the Amazon rainforest. Phytotaxa 231(2): 187–192. http://dx.doi.org/10.11646/phytotaxa.231.2.8

Rossi W, Bernardi M, Torres JA. 2016a. New species of *Laboulbenia* parasitic on leaf beetles. Mycological Progress 15(1): 4 [on-line, 7 p.]. http://dx.doi.org/10.1007/s11557-015-1146-8

Rossi W, Haelewaters D, Pfister DH. 2016b. Fireworks under the microscope: a spectacular new species of *Zodiomyces* from the Thaxter collection. Mycologia 108: 709–715. http://dx.doi.org/10.3852/15-148

Santamaría S. 1998. *Laboulbeniales*. I. *Laboulbenia*. Flora Mycologica Iberica 4. 186 p.

Spegazzini C. 1917. Revisión de las *Laboulbeniales* Argentinas. Anales del Museo Nacional de Historia Natural de Buenos Aires 29: 445–688.

Sugiyama K, Majewski T. 1987. On new species of the genus *Laboulbenia* (*Laboulbeniomycetes*, *Ascomycotina*) III. Transactions of the Mycological Society of Japan 28: 121–136.

Tavares II. 1985. *Laboulbeniales* (*Fungi*, *Ascomycetes*). Mycologia Memoir 9. 627 p.

Thaxter R. 1931. Contribution towards a monograph of the *Laboulbeniaceae*. Part V. Memoirs of the American Academy of Arts and Sciences 16: 1–435, plates I–LX. http://dx.doi.org/10.2307/25058136

Wang TW. 2014. *Laboulbeniales:* the little fungi that could. Inoculum 65(6): 2–3.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 621–629

http://dx.doi.org/10.5248/131.621

Erysiphe acantholimonis sp. nov. on *Acantholimon hedinii*

Jia-Ge Song[1], Biao Xu[1], Shan-He Zhang[1],
Zhen-Yu Zhao[1], Sung-Eun Cho[2] & Hyeon-Dong Shin[2*]

[1]*College of Life Sciences, Tarim University & Province-Ministry Joint Key Laboratory of Protection and Utilization of Biological Resources in Tarim Basin, Alar 843300, China*

[2]*Division of Environmental Science and Ecological Engineering, Korea University, Seoul 02841, Korea*

[*] Correspondence to: *hdshin@korea.ac.kr*

Abstract—A powdery mildew on *Acantholimon hedinii* was collected in China, examined, described, and proposed as a new species, *Erysiphe acantholimonis*. Recognition of this new species is supported by phylogenetic analyses of the internal transcribed spacer regions including 5.8S and 28S rDNA sequences from three *E. acantholimonis* specimens. A comparison with and a key to the three species of *Erysiphe* on hosts belonging to the family *Plumbaginaceae* are provided.

Key words—*Erysiphaceae, Erysiphe aurea, Erysiphe limonii,* ITS, molecular phylogeny

Introduction

Powdery mildews (*Erysiphaceae*) are holobiotrophic fungi pathogenic on plant leaves, stems, flowers, and fruits. These pathogens cause moderate to serious damage in nearly 10,000 species of angiosperms (Amano 1986, Glawe 2008). Braun (1987) introduced a classification of the *Erysiphaceae* that split the family into 18 genera, including *Erysiphe*, *Microsphaera*, and *Uncinula.* On the basis of phylogenetic analyses, Braun & Takamatsu (2000) subsequently reduced these three genera to synonymy under *Erysiphe* (sensu lato), which they separated into three non-phylogenetic sections: *E.* sect. *Erysiphe, E.* sect. *Microsphaera,* and *E.* sect. *Uncinula*. *Erysiphe* sect. *Erysiphe* is characterized by having chasmothecia with mycelioid appendages.

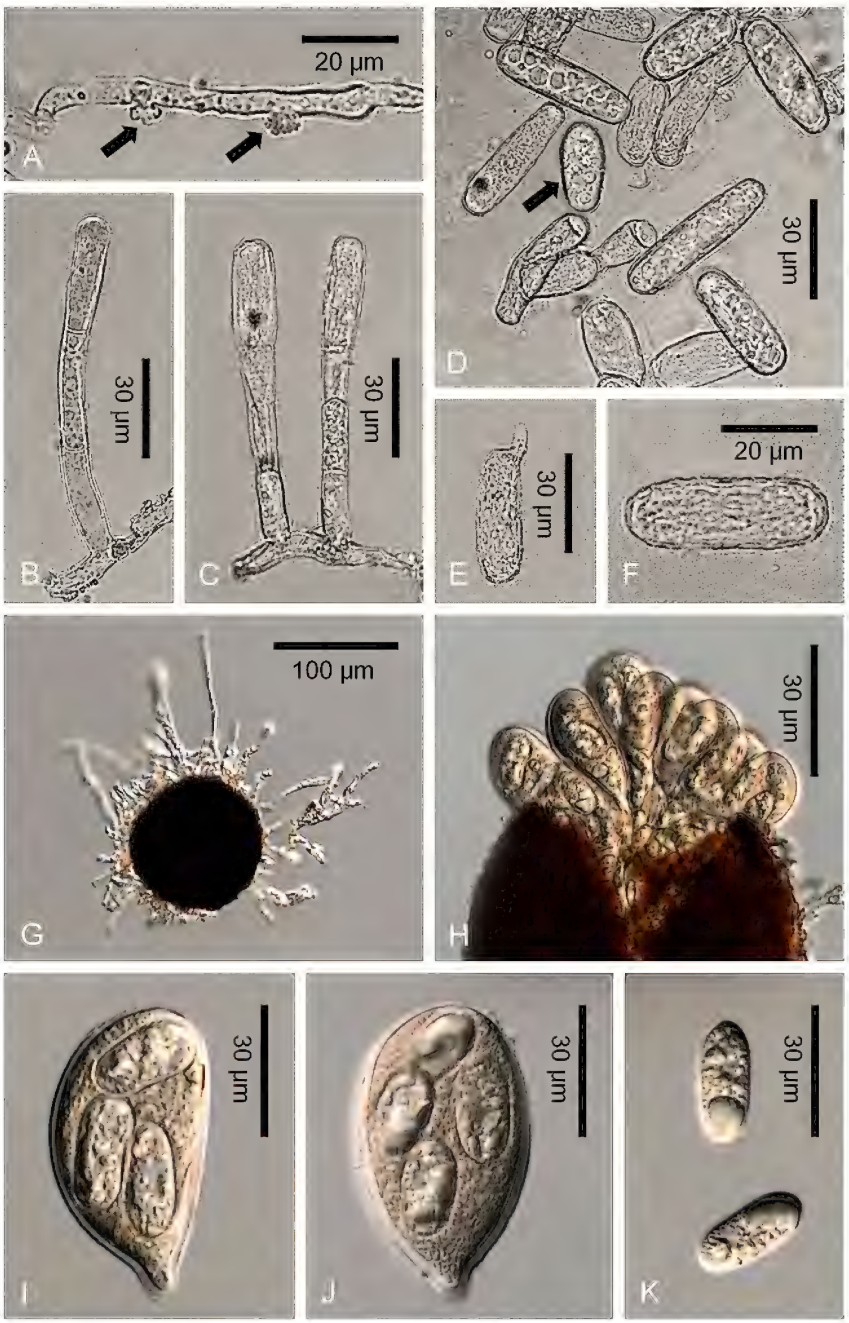
Two species of *Erysiphe* sect. *Erysiphe*, *E. aurea* R.Y. Zheng & G.Q. Chen and *E. limonii* L. Junell, have been described on plants within the family *Plumbaginaceae*. In 2010, a powdery mildew occurring on *Acantholimon* (*Plumbaginaceae*) was found in Xinjiang, China, which Song et al. (2015) reported as the first record of *Erysiphe limonii* on *A. hedinii* from China. However, a detailed morphological re-examination and molecular analyses have revealed that powdery mildew on this host is clearly distinct from *E. limonii*. Here, we propose the fungus collected on *A. hedinii* as a new species, *E. acantholimonis,* and base our description on a morphological characterization and DNA sequence comparison. In addition, we discuss relationships of the new species to closely related powdery mildew fungi.

Materials & methods

Fungal structures were detached from the infected leaves and mounted in a few drops of distilled water on a glass slide for light microscopy. Morphological characteristics of the fungal structures were examined in bright field and differential interference contrast (DIC) light microscopy, using an Olympus BX51 microscope (Olympus, Tokyo, Japan) for measurements and a Zeiss AX10 microscope equipped with AxioCam MRc5 (Carl Zeiss, Göttingen, Germany) for photographs. Elements were measured at 100×, 200×, 400×, and 1000× magnifications. Representative voucher specimens were deposited in the Mycological Herbarium of Tarim University, Xinjiang, China (HMUT), and the Korea University Herbarium, Seoul, Korea (KUS).

Genomic DNA was extracted from chasmothecia using the Chelex 100 method as set forth in Walsh et al. (1991) and Hirata & Takamatsu (1996). The 28S ribosomal DNA (rDNA) including domains D1 and D2 and the internal transcribed spacer (ITS) regions including ITS1, 5.8S, and ITS2 were amplified by polymerase chain reaction (PCR) using the primer pairs ITS1/ITS4 (White et al. 1990) for ITS, and PM3 (Takamatsu & Kano 2001) and TW14 (Mori et al. 2000) for 28S. The PCR products were then sequenced directly (Takamatsu et al. 2009) by a commercial sequencing company (Macrogen, Seoul, Korea) using the same primers used for PCR. The resulting sequences were deposited in GenBank (Accession Nos. KU554532–KU554537). The sequences were used in a BLASTn search against the NCBI nucleotide databases to confirm the identity of the isolates. The sequences were aligned with published sequences of *E.* sect. *Erysiphe* species retrieved from GenBank, using the online version of MAFFT ver. 7.215 (Katoh et al. 2002). *Neoerysiphe galeopsidis* (DC.) U. Braun was used as an outgroup. Maximum Likelihood (ML) analyses were performed using RAxML-HPC BlackBox ver. 8.2.4 (Stamatakis 2006, Stamatakis et al. 2008) in the CIPRES cluster server (http://www.phylo.org/) at the San Diego Supercomputer Center.

Fig. 1. *Erysiphe acantholimonis* (holotype, HMUT00821). A: hypha with appressoria (arrows); B, C: conidiophores; D: conidia (arrow indicates a primary conidium); E: germinating conidium; F: surface structure of a wrinkled conidium; G: chasmothecium with appendages; H: chasmothecium containing several asci; I, J: asci containing 3–4 ascospores; K: ascospores.


20 µm
A
30 µm
B
30 µm
C
30 µm
D
30 µm
E
20 µm
F
100 µm
G
30 µm
H
30 µm
I
30 µm
J
30 µm
K

Taxonomy

Erysiphe acantholimonis J.G. Song, B. Xu & H.D. Shin, **sp. nov.** Fig. 1

MycoBank MB 815918

Differs from *Erysiphe limonii* by its larger conidial length/width ratio, its smaller 2–4-spored asci, and its *Acantholimon* host.

Type: China, Xinjiang, Wuqia county, 39°53′17″N 74°56′47″E, on *Acantholimon hedinii* Ostenf. (*Plumbaginaceae*), 29 Aug. 2010, B. Xu (**holotype**, HMUT00821; **isotype**, KUS-F29047; GenBank KU554537, KU554536).

Etymology: The epithet is derived from the host genus, *Acantholimon*.

Colonies amphigenous, thinly effused or conspicuous, forming circular to irregular white patches. Hyphae straight or almost so, branched, hyaline, septate, 4–8 µm diam. Hyphal appressoria well-developed, moderately lobed to multi-lobed, solitary or in opposite pairs, 4–9 µm diam. Conidiophores arising from the upper part of mother cells, 72–105 × 6.5–9.0 µm, producing conidia singly. Foot-cells mostly straight or almost so, cylindrical, 17–38 µm long, relatively short, followed by 2–3 shorter cells. Conidia hyaline, cylindrical-oval to oblong, 30–50 × 11–15 µm with a length/width ratio of 2.0–4.1, lacking fibrosin bodies, producing germ tubes in a perihilar position, with an angular/rectangular wrinkling pattern on the surface. Primary conidia apically rounded, basally subtruncate, generally smaller than the secondary conidia. Chasmothecia amphigenous, cauligenous, gregarious, dark brown, spherical, 80–130 µm diam, containing 5–10 asci. Peridium cells irregularly polygonal or rounded, 10–20 µm diam, inner wall of the peridium cells yellowish to hyaline. Appendages few to numerous, 0–1-septate, mycelioid, 0.5–1 times as long as the chasmothecial diameter, 50–100 × 7.5–9.0 µm, tips distinctly recurved, brown at the base, becoming paler toward the tip. Asci obovoid to ellipsoid or saccate, mostly short-stalked, 52–68 × 32–40 µm, containing 2–4 spores per ascus. Ascospores oblong-ovoid, hyaline, guttulate, 25–32 × 12–15 µm.

Additional specimens examined: **on *Acantholimon hedinii*: CHINA, Xinjiang, Wuqia county,** 19 Jun. 2010, B. Xu (HMUT00507, KUS-F29044); 28 Aug. 2010, B. Xu (HMUT01489, KUS-F29046; GenBank KF318724, KU554532); **Wensu county,** 24 Aug. 2010, B. Xu (HMUT00396, KUS-F29045; GenBank KU554535, KU554534).

Host range and distribution: on *Acantholimon hedinii* (China, endemic).

Phylogenetic analyses

Additional specimen sequenced: ***Erysiphe limonii*: KOREA, Iksan,** 11 May 2013, H.D. Shin (KUS-F27301; GenBank KU554533).

The GenBank BLAST search of the examined powdery mildew isolates showed that *E. acantholimonis* on *A. hedinii* belongs to *E.* sect. *Erysiphe*. Based on the

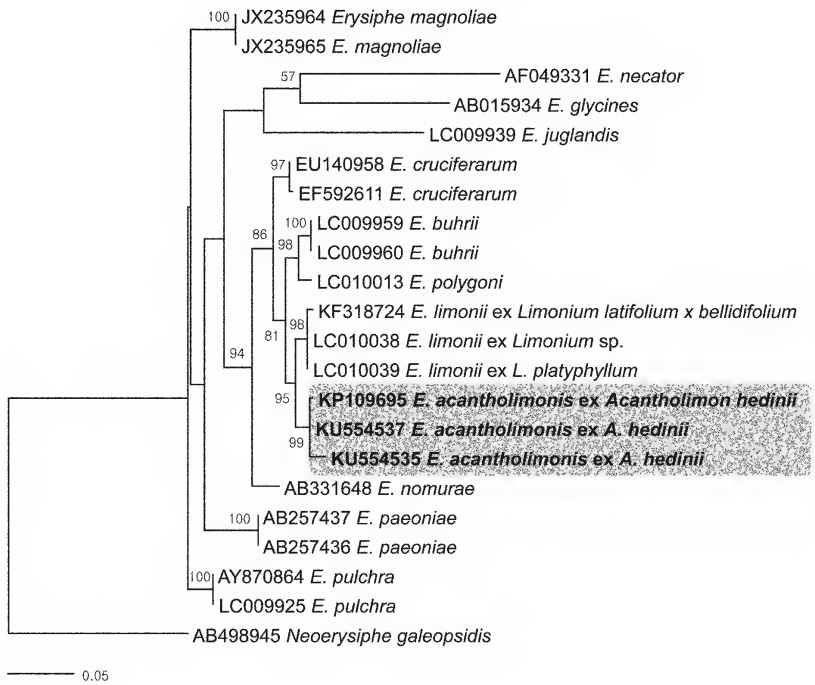


FIG. 2. ITS (including 5.8S rDNA) phylogenetic relationship between *Erysiphe acantholimonis* isolates and reference isolates retrieved from GenBank, inferred by RAxML analysis. Sequences of *E. acantholimonis* are shown in bold and their clade is highlighted in gray. Numbers above the branches represent bootstrap support values >50% obtained from 1000 bootstrap replicates. Scale bar indicates the number of substitutions per site.

molecular phylogenetic trees generated from the RAxML analyses of the ITS and 28S rDNA, sequences generated from the three *E. acantholimonis* isolates formed an independent clade with bootstrap (BS) supports of 99% for ITS (FIG. 2) and 86% for 28S (FIG. 3). The clade of the new fungus was clearly separated from *E. limonii* from Korea (KF318724 and KU554533 ex *Limonium latifolium* × *bellidifolium*) and Ukraine (LC010038 ex *Limonium* sp.; and LC010039 ex *L. platyphyllum*) in the RAxML trees. In addition, *E. acantholimonis* was shown to be a sister species to *E. limonii* with BS supports of 95% for ITS (FIG. 1) and 98% for 28S (FIG. 3), suggesting a close phylogenetic relationship. Thus the status of *E. acantholimonis* as a new species is fully supported by the molecular sequence analyses.

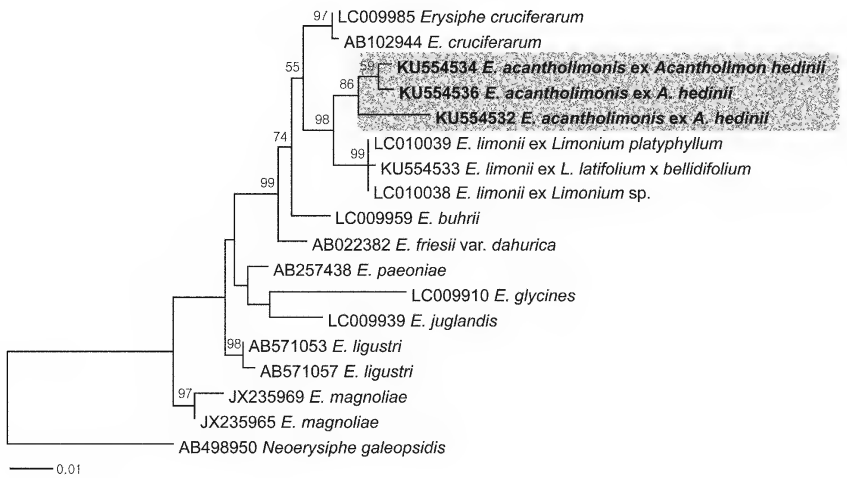


FIG. 3. 28S rDNA phylogenetic relationships between *Erysiphe acantholimonis* isolates and reference isolates retrieved from GenBank, inferred by RAxML analysis. Sequences of *E. acantholimonis* are shown in bold and their clade is highlighted in gray. Numbers above the branches represent bootstrap support values >50% obtained from 1000 bootstrap replicates. Scale bar indicates the number of substitutions per site.

Discussion

Two *Erysiphe* species belonging to *E.* sect. *Erysiphe* have previously been recorded as occurring on *Plumbaginaceae* worldwide (Braun & Cook 2012, Farr & Rossman 2016). *Erysiphe limonii*, found from Europe to Asia on various *Limonium* spp., is morphologically similar to *E. aurea* but differs by having appendages with some septa, 3–8 asci, and an inner peridial wall that is not golden yellow (Braun & Cook 2012). The phylogenetic status of *E. limonii* was recently resolved (Takamatsu et al. 2015, Choi et al. 2016), resulting in a characterization based on morphological observations and a molecular sequence analysis. *Erysiphe aurea* was described from a single collection on *Limonium suffruticosum* in China (Zheng & Chen 1980, Braun & Cook 2012); it is distinguished from *E. limonii* in having aseptate appendages and an inner peridial wall composed of golden-yellow cells. The conidial state of *E. aurea* is inadequately known, and molecular data are not yet available for

phylogenetic analyses. Therefore, additional material is needed to ascertain the taxonomic status of *E. aurea*, and to clarify its relationship to *E. limonii* and *E. acantholimonis*.

Erysiphe limonii differs from *E. acantholimonis* by its larger, 3–6-spored asci (45–85 × 25–50 µm) and smaller conidial length/width ratio (1.6–2.9; Choi et al. 2016), while *E. aurea* differs from *E. acantholimonis* by its longer and narrower (60–80 × 25–35 µm) 4–6-spored asci and golden yellow inner peridial wall.

Acantholimon comprises about 200 species worldwide (Dogan & Akaydin 2004). Recent molecular phylogenetic studies (Lledó et al. 2005, Moharrek et al. 2014) have shown that *Limonium* and *Acantholimon* are not closely related, suggesting that the *Acantholimon* and *Limonium* powdery mildews are unlikely to be accepted as conspecific. Amano (1986) listed *Acantholimon avenaceum*, *A. kotschyi*, and *Acantholimon* sp. as hosts of *E. limonii*. Additional morphological and molecular data are needed to supplement our current knowledge about powdery mildews infecting *Acantholimon* spp.

DNA sequence comparisons based on the ITS and 28S rDNA data obtained from the analyzed *Acantholimon* specimens place their powdery mildew fungus in *E.* sect. *Erysiphe*. In addition, the results indicate that *E. limonii* and *E. acantholimonis* may have diverged along with their plumbaginaceous hosts. Results obtained from the phylogenetic analyses are further supported by morphological data, showing that *E. acantholimonis* is a distinct species occurring on *A. hedinii* in China. Based on the information obtained from literature as well as our own data, we provide a key to the three species of *Erysiphe* occurring on *Plumbaginaceae*:

Key to *Erysiphe* species known on *Plumbaginaceae*

1. Inner peridial wall golden yellow; appendages aseptate ..... ***E. aurea***
1. Inner peridial wall not golden yellow; appendages at least partly septate 2
2. Asci relatively large (45–85 × 25–50 µm), 3–6-spored;
   median conidial length/width ratio <3.0 ..... ***E. limonii***
2. Asci relatively small (52–68 × 32–40 µm), 2–4-spored;
   median conidial length/width ratio mostly >3.0 ..... ***E. acantholimonis***

Acknowledgements

The authors are grateful to Uwe Braun (Martin Luther University, Halle, Germany) and Susumu Takamatsu (Mie University, Tsu, Japan) for critical comments on the manuscript. This work was supported by the National Natural Science Foundation of China (Nos. 31360007, 31460008) and the BK21 Plus program in 2016–2020 funded by the National Research Foundation of Korea (NRF).

Literature cited

Amano K. 1986. Host range and geographical distribution of the powdery mildew fungi. Japan Scientific Societies Press, Tokyo.

Braun U. 1987. A monograph of the *Erysiphales* (powdery mildews). Beih. Nova Hedwigia 89. 700 p.

Braun U, Cook RTA. 2012. Taxonomic manual of the *Erysiphales* (powdery mildews). CBS Biodiversity Series 11. 707 p.

Braun U, Takamatsu S. 2000. Phylogeny of *Erysiphe, Microsphaera, Uncinula* (*Erysipheae*) and *Cystotheca, Podosphaera, Sphaerotheca* (*Cystotheceae*) inferred from rDNA ITS sequences – some taxonomic consequences. Schlechtendalia 4: 1–33.

Choi IY, Choi CH, Cho SE, Park JH, Shin HD. 2016. First report of powdery mildew caused by *Erysiphe limonii* on perennial hybrid statice in Korea. Plant Dis. 100: 652. http://dx.doi.org/10.1094/PDIS-08-15-0893-PDN

Dogan M, Akaydin G. 2004. Three new species with two flowered spikelets in *Acantholimon* (*Plumbaginaceae*) from East Anatolia, Turkey. Bot. J. Linn. Soc. 144: 497–505. http://dx.doi.org/10.1111/j.1095-8339.2003.00267.x

Farr DF, Rossman AY. 2016. Fungal databases. Syst. Mycol. Microbiol. Lab., Online publication, ARS, USDA. Retrieved January 4, 2016.

Glawe DA. 2008. The powdery mildews: a review of the world's most familiar (yet poorly known) plant pathogens. Ann. Rev. Phytopathol. 46: 27–51. http://dx.doi.org/10.1146/annurev.phyto.46.081407.104740

Hirata T, Takamatsu S. 1996. Nucleotide diversity of rDNA internal transcribed spacers extracted from conidia and cleistothecia of several powdery mildew fungi. Mycoscience 37: 283–288. http://dx.doi.org/10.1007/BF02461299

Katoh K, Misawa K, Kuma K, Miyata T. 2002. MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. Nucleic Acids Res. 30: 3059–3066.

Lledó MD, Crespo MB, Fay MF, Chase MW. 2005. Molecular phylogenetics of *Limonium* and related genera (*Plumbaginaceae*): biogeographical and systematic implications. Amer. J. Bot. 92: 1189–1198. http://dx.doi.org/ 10.3732/ajb.92.7.1189

Moharrek F, Kazempour Osaloo S, Assadi M. 2014. Molecular phylogeny of *Plumbaginaceae* with emphasis on *Acantholimon* Boiss. based on nuclear and plastid DNA sequences in Iran. Biochem. Syst. Ecol. 57: 117–127. http://dx.doi.org/ 10.1016/j.bse.2014.07.023

Mori Y, Sato Y, Takamatsu S. 2000. Evolutionary analysis of the powdery mildew fungi using nucleotide sequences of the nuclear ribosomal DNA. Mycologia 92: 74–93. http://dx.doi.org/10.2307/3761452

Song JG, Xu B, Zhang SH, Zhao ZY. 2015. First report of powdery mildew caused by *Erysiphe limonii* on *Acantholimon hedinii* in China. Plant Dis. 99: 1038. http://dx.doi.org/10.1094/PDIS-12-14-1339-PDN

Stamatakis A. 2006. RAxML-VI-HPC: maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. Bioinformatics 22: 2688–2690.

Stamatakis A, Hoover P, Rougemont J. 2008. A rapid bootstrap algorithm for the RAxML web servers. Syst. Biol. 57: 758–771. http://dx.doi.org/10.1080/10635150802429642

Takamatsu S, Kano Y. 2001. PCR primers useful for nucleotide sequencing of rDNA of the powdery mildew fungi. Mycoscience 42: 135–139. http://dx.doi.org/10.1007/BF02463987

Takamatsu S, Heluta V, Havrylenko M, Divarangkoon R. 2009. Four powdery mildew species with catenate conidia infect *Galium*: molecular and morphological evidence. Mycol. Res. 113: 117–129. http://dx.doi.org/10.1016/j.mycres.2008.09.006

Takamatsu S, Ito H, Shiroya Y, Kiss L, Heluta V. 2015. First comprehensive phylogenetic analysis of the genus *Erysiphe* (*Erysiphales*, *Erysiphaceae*) I. The *Microsphaera* lineage. Mycologia 107: 475–489. http://dx.doi.org/10.3852/15-007

Walsh PS, Metzger DA, Higuchi R. 1991. Chelex 100 as a medium for simple extraction of DNA for PCR-based typing from forensic material. BioTechniques 10: 506–513.

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal genes for phylogenetics. 315–322, in: MA Innis et al. (eds). PCR protocols: a guide to methods and applications. San Diego, Academic Press. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

Zheng RY, Chen GQ. 1980. Taxonomic studies on the genus *Erysiphe* of China. II. New species, new variety and new combination on *Berberidaceae*, *Begoniaceae* and *Plumbaginaceae*. Acta Microbiol. Sin. 20: 356–364.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 631–638

http://dx.doi.org/10.5248/131.631

Tubulicrinis martinicensis sp. nov., a corticioid species from Martinique (French West Indies)

Gérald Gruhn [1*], Nils Hallenberg [2] & Régis Courtecuisse [3]

[1] *Office National des Forêts, Réseau mycologique, 5 avenue Mirandol, F-48000 Mende, France*

[2] *Hessgade 35, DK-5500 Middelfart, Denmark*

[3] *Université de Lille (Laboratoire des sciences végétales et fongiques - LSVF), B.P.83, F-59006 Lille Cedex, France*

* Correspondence to: *gerald.gruhn@onf.fr*

Abstract—The new species *Tubulicrinis martinicensis*, collected in Martinique Island (French West Indies), is described and illustrated. The differences from other species with cylindric cystidia with obtuse apex are discussed, and this new species is included in the key to the species of *Tubulicrinis* known worldwide.

Key words—*Basidiomycota, Tubulicrinaceae, Hymenochaetales*

Introduction

Mycological inventories initiated by R. Courtecuisse have been carried out in French West Indies for several years on behalf of the French forestry office (Office National des Forêts; Courtecuisse 2006, Voiry & Courtecuisse 2012, Courtecuisse & Welti 2013). Several new species (primarily in *Agaricomycetes* and *Sordariomycetes*) have been described in this project; here we describe the first new corticioid species.

Tubulicrinis Donk is a morphologically well-delimited corticioid genus belonging to the family *Tubulicrinaceae* Jülich (Jülich 1982) in the order *Hymenochaetales* Oberw. (Frey et al. 1977). Its key character is the presence of long cystidia with thick walls and multiple roots, dissolving in KOH (Hjortstam et al. 1988, Bernicchia & Gorjón 2010) and often strongly amyloid (Larsson 2007). The type species, *T. glebulosus* (Bres.) Donk, is non-typified (Hjortstam 2001) and closely related to *T. gracillimus* (Ellis & Everh. ex D.P. Rogers & H.S. Jacks.) G. Cunn.

In this article, we describe as new and illustrate *T. martinicensis,* discuss its similarities and differences to closely related species, and propose a modification of the worldwide key to the genus by Hjortstam (2001).

Materials & methods

Macroscopic and microscopic studies were based on fresh and dried material. Sections were prepared with a razor blade and observed in several solutions: ammoniacal Congo Red, 3% KOH with additions of 1% phloxine B, Melzer's, and Cotton Blue. The dissolution time of cystidia was computed using 3% KOH. Measurements were done on photos taken from the microscope under 1000× magnification, using Mycomètre software (Fannechère 2011). In spore measurements the following format was used: "N; (minimum–) d1–d9 (–maximum) µm", where "N" is the number of spores in the sample and "d1"and "d9" are the 1st and 9th decile measurements (Fannechère 2005). Spore measurements were based on spores seen in profile and obtained from a spore print (Duhem 2010), in Melzer's.

Specimens are conserved in the Herbarium, Département de Botanique, Université de Lille, Lille, France (LIP); the Herbarium, Department of Biological and Environmental Sciences, University of Gothenburg, Göteborg, Sweden (GB); and the private herbariums of G. Gruhn (hb. Gruhn) and F. Dämmrich (hb. Dämmrich). Additional material was examined from the Herbarium, Université Claude Bernard, Lyon, France (LY) and from the private herbariums of M. Gérard (hb. Gérard) and G. Trichies (hb. Trichies).

Tubulicrinis martinicensis G. Gruhn, Hallenb. & Courtec., **sp. nov.** FIGS 1–3

MycoBank MB 815644

Differs from *Tubulicrinis confusus* by its narrower spores.

TYPE: French West Indies, Martinique, Les Anses d'Arlet, Grande Anse, Morne Champagne, on deeply white-rotted wood of undetermined deciduous tree, in a xerophilic coastal forest, 7 July 2012, leg. R. Courtecuisse (**Holotype**, LIP GG-MAR12-206. **Isotypes**, hb. Gruhn MAR12-206; hb.Dämmrich D11157; GB).

ETYMOLOGY: *martinicensis* epithet refers to the site of collection.

BASIDIOME annual, effused (30 × 10 cm), adnate, strongly attached to the wood, cream-colored when fresh, irregularly cracked into polygons. Light ochraceous and concolorous with the supporting wood when dry. HYMENIUM uneven when fresh, smooth when dry. CONTEXT homogeneous, not stratified, concolorous with the hymenium in the whole profile, 250–300 µm thick, cracking into pieces when dry. Margin thin and distinct, frequently floccose, concolorous with the hymenium. SPORE PRINT white.

HYPHAL SYSTEM monomitic, context made up of a dense hyphal texture; clamp connections present at all septa; hyphae thin-walled and smooth in context but slightly thick-walled in subiculum, thin-walled in subhymenium, 2–3 µm in diam., non amyloid. LYOCYSTIDIA smooth, irregularly cylindrical, distinctly sinuous in the upper part and rounded at apex, without crystals. Wall

Fig. 1. ***Tubulicrinis martinicensis*** (holotype, LIP GG-MAR12-206), fresh material. Scale bar = 2 cm. Photo G. Gruhn.

thick (2–4 µm) at the base and slightly amyloid. About two thirds of the outer wall is irregularly inflated. Upwards, the wall becomes gradually thinner up to the top and is quite thin along the apical third of the length (30–40 µm). Total dimensions: (60–)80–92(–112) × 7–7.5(–9) µm, the wider part located in the middle of the length. Near the apex sometimes slightly clavate with a diameter of 4.5–5.5 µm. Lumen usually symmetrical. Cystidia originate deep in the context, projecting up to 50–65 µm above the level of the hymenium; multiple roots have not been observed; external cystidial wall dissolving in 3% KOH between 3 to 20 minutes. Basidia in a dense hymenium, short clavate, 9–12(–15) × 3.5–4 µm, with one or several minor constrictions, thin-walled, contents homogenous; sterigmata 4, thin, 3 µm long, inamyloid. Basidiospores subcylindrical to suballantoid, multiguttulate, N = 44, (5.1–)5.6–7.0(–7.1) × (1.8–)1.9–2.6 µm, Qm = 2.9; thin-walled and smooth, inamyloid, non-dextrinoid, non-cyanophilous.

Additional specimens examined:

Tubulicrinis gracillimus: **FRANCE**, Vendée, Île d'Yeu, between St-Sauveur and Port de la Meule,. on *Quercus ilex*, leg. M. Gérard, det. B. Duhem (hb.Gérard MG2440); **Moselle**, commune de Moyeuvre, Forêt Domaniale de Moyeuvre, on decorticated *Betula*, leg. & det. G. Trichies (hb. Trichies GT00612). **SWITZERLAND**, **Bern**, Berner Oberland, Grindelwald, on *Juniperus* sp., leg. & det. F. Dämmrich (hb. Dämmrich D8312).

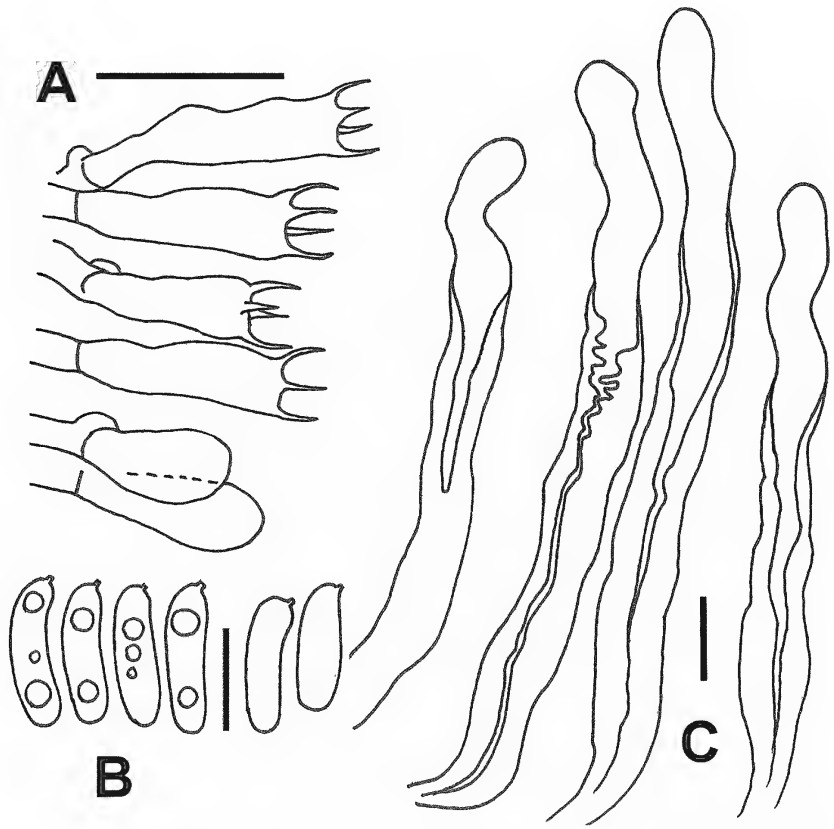


Fig. 2. ***Tubulicrinis martinicensis*** (holotype, LIP GG-MAR12-206), hymenial details observed in KOH-phloxine. A. mature and young basidia; B. spores C. cystidia.
Scale bars: A, C = 10 µm; B = 5 µm. Drawings G. Gruhn.

Tubulicrinis incrassatus: **FRANCE**, **Rhône**, St-Martin-en-Haut, lieu-dit le Bois de Remayou, on *Pinus sylvestris*, leg. & det. G. Gruhn, conf. N. Hallenberg (hb. Gruhn GG-151011-016). **FRENCH WEST INDIES**, **Guadeloupe**, Basse-Terre, Carrère, on dead stump, leg. & det. J. Boidin (LY JB-8106).

Discussion

Tubulicrinis martinicensis is well characterized by the shape of its long tubular cystidia with obtuse apices and by its narrow slightly allantoid spores.

The new species is close to *T. gracillimus*, which shows long cylindrical lyocystidia with a weak amyloid reaction. The shape of the lyocystidia is similar

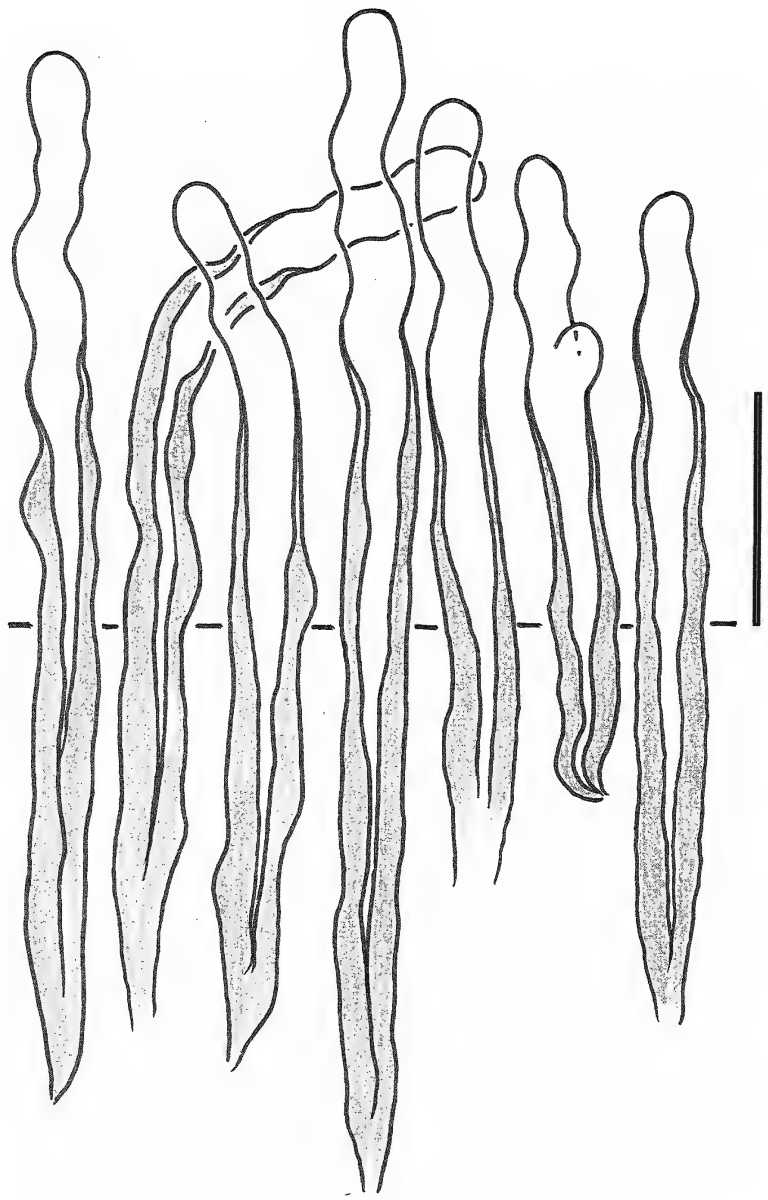


FIG. 3. ***Tubulicrinis martinicensis*** (holotype, LIP GG-MAR12-206).
Cystidia observed in Melzer's, with the horizontal line showing the emergence level.
Scale bar = 25 µm. Drawings G. Gruhn.

in both species, including a rounded apex without crystals, but in *T. gracillimus* the thin-walled upper part is short, less than 20 µm long (Hjortstam & Larsson 1988). Moreover, the spores of *T. gracillimus* are longer and narrower (7.5–8.5 × 1.75–2.0 µm; Hjortstam & Larsson 1988).

Tubulicrinis confusus K.H. Larss. & Hjortstam is a rare species described from Norway (Hjortstam & Larsson 1986). The cystidia are distinctly sinuous, like those of *T. martinicensis*, but the diameters are smaller and become narrower towards apex (Hjortstam et al. 1988), in contrast to the Martinique species where the diameter widens towards the apex. Moreover, the spores of *T. confusus* are ellipsoid and wider (2.8–3.5 µm diam.; Hjortstam et al. 1988), and its basidiome is odontioid in mature specimens.

Neither can *T. martinicensis* be confused with *T. pseudoborealis* Boidin & Gilles, a tropical species known only from a single collection from Réunion Island (Hjortstam & Ryvarden 2007). The spore dimensions are similar with those of *T. martinicensis*, but the spore shape is ellipsoid to cylindrical. Also, the thin-walled upper part of the lyocystidia is shorter and not sinuous, and the basidiome is thin and porulose (Boidin & Gilles 1988).

Finally, the spores of *T. martinicensis* are close to those of *T. incrassatus* Hallenb., which differs by its typically non-symmetrical cystidia (Hallenberg 1978, Hjortstam & Ryvarden 2007, Bernicchia & Gorjón 2010, Gruhn & Rivoire 2016).

Key to *Tubulicrinis* incorporating *T. martinicensis*

Hjortstam (2001) published a key to known *Tubulicrinis* species, which we propose to modify by inserting *T. martinicensis* [boldface] as follows:

24a (23b). Spores ellipsoid or subcylindrical 25
24b. Spores cylindrical to allantoid 26

25a (24a). Cystidia distinctly sinuous 34
25b. Cystidia otherwise. Réunion ..... ***T. pseudoborealis***

//BREAK//

30a (29b). Basidiomes thick, often cracking conspicuously 31
30b. Basidiomes thinner 32

31a (30a). Spores 5.5–7 × 1.8–2 µm 33
31b. Spores 6.0–9.0 × 1.5–2.25 µm.
Common species, preferably on deciduous wood
(In its broad sense a cosmopolitan species. Note *T. gracillimus*,
which seems to be very close morphologically.) ..... ***T. glebulosus***

32a (30b). Cystidia widened towards the apex, spores 6–8 × 1.5–1.8(–2) µm.
Rather common in Northern Europe,
also from North America ..... ***T. medius***

32b. Cystidia with subcapitate apex, spores 5.5–9.5 × 1.5–1.8 µm.
North America and Europe, rare species ..... ***T. propinquus***

33a (31a). Cystidia sinuous with symmetric lumen.
Caribbean ..... ***T. martinicensis***

33b. Cystidia otherwise, with typical asymmetric lumen.
Southern Europe, Iran, Caribbean ..... ***T. incrassatus***

34a (25a). Cystidia slightly acute, spores 2.8–3.5 µm wide ..... ***T. confusus***

34b. Cystidia not acute, merely expanding at apex,
spores <2.5 µm wide ..... ***T martinicensis***

Acknowledgments

The authors thank Gérard Trichies, Maurice Gérard and Franck Dämmrich for loan of herbarium specimens. They also thank Dr Isabel Salcedo (UPV/EHU) and Dr Genevieve Gates (UTAS) for peer reviewing. Collection of the type specimen has been done during missions of the "Inventaire mycologique des Petites Antilles: diversité, écologie et protection" headed by one of us since 2003 (RC). For these missions, we thank the financial partners in 2012: Office National des Forêts (direction générale et direction régionale Martinique) and DEAL-Martinique (Direction de l'écologie, de l'aménagement et du logement). The Société Mycologique de France is also thanked for its help in the financial management of the field trips.

Literature cited

Bernicchia A, Gorjón SP. 2010. *Corticiaceae* s. l. Fungi Europaei 12. Ed. Candusso, Italia.

Boidin J, Gilles G. 1988. Basidiomycètes Aphyllophorales de l'Île de la Réunion X - Compléments aux genres traités antérieurement (1re partie). Bulletin de la Société Mycologique de France 104(2): 59–72.

Courtecuisse R. 2006. Liste préliminaire des *Fungi* recensés dans les îles françaises des Petites Antilles: Martinique, Guadeloupe et dépendances. I. Basidiomycètes lamellés et affines (*Agaricomycetideae s.l.*). Documents Mycologiques 34(133–134): 81–140.

Courtecuisse R, Welti S. 2013. Liste préliminaire des *Fungi* recensés dans les îles françaises des Petites Antilles: Martinique, Guadeloupe et dépendances. II – Basidiomycètes non lamellés (espèces gastéroïdes, rouilles et charbons exclus). Documents Mycologiques 35: 47–173.

Duhem B. 2010. Éléments pour une approche de l'étude des corticiés. I. La sporée. Bulletin de la Société Mycologique de France 126(2): 143–160.

Fannechère G. 2005. Statistiques et notation des dimensions des spores. Bulletin de la Société Mycologique de France 121(3–4): 255–292.

Fannechère G. 2011. Mycomètre 2.05. http://mycolim.free.fr/sml/gener/logiciels1.html

Frey W, Hurka H, Oberwinkler F. 1977. Beiträge zur Biologie der niederen Pflanzen. Gustav Fischer Verlag, Stuttgart. 233 p.

Gruhn G, Rivoire B. 2016. *Tubulicrinis incrassatus* (*Basidiomycota*), première récolte en France métropolitaine. Bulletin de la Société Linnéenne de Lyon 85(7–8): 241–245.

Hallenberg N. 1978. Wood fungi (*Corticiaceae, Coniophoraceae, Lachnocladiaceae, Thelephoraceae*) in N. Iran. I. Iranian Journal of Plant Pathology 14: 38–87.

Hjortstam K. 2001. *Tubulicrinaceae*, a survey of the genera and species. Windahlia 24: 1–14.

Hjortstam K, Larsson KH. 1986. Notes on *Corticiaceae* (*Basidiomycetes*) XV. Some new species from Northern Europe. Mycotaxon 26: 437–443.

Hjortstam K, Ryvarden L. 2007. Checklist of corticioid fungi (*Basidiomycota*) from the tropics, subtropics, and the southern hemisphere. Synopsis Fungorum 22: 27–146.

Hjortstam K, Larsson KH, Ryvarden L. 1988. The *Corticiaceae* of North Europe. *Phlebia*, *Thanatephorus*, *Ypsilonidium*. Fungiflora 8: 1450–1631.

Jülich W. 1982 ["1981"]. Higher taxa of *Basidiomycetes*. Bibliotheca Mycologica. 85. 485 p.

Larsson KH. 2007. Re-thinking the classification of corticoid fungi. Mycological Research 111(9): 1040–1063. http://dx.doi.org/10.1016/j.mycres.2007.08.001

Voiry H, Courtecuisse R. 2012. Cinq ans d'inventaire mycologique en forêt de Martinique et de Guadeloupe, premiers résultats. Rendez-vous Techniques ONF 80: 57–63.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 639–643

http://dx.doi.org/10.5248/131639

Roccella elisabethae with lichenicolous *Arthonia follmanniana* in Turkey

Mehmet Gökhan Halici & Arife Merve Kahraman

University of Erciyes, Faculty of Science, Department of Biology, 38039 Kayseri, Turkey

Correspondence to: *mghalici@gmail.com*

Abstract—*Roccella elisabethae* and the lichenicolous fungus *Arthonia follmanniana* growing on it are reported for the first time from Turkey. Comments on their habitats, substrata, and key anatomical features are provided for each species along with habit photographs and photographs of microscopic features of the *Arthonia* that have not previously been illustrated.

Key words—*Ascomycota*, Beşparmak Island, lichens, lichenized fungi, Mersin

Introduction

Studies on the lichenized and lichenicolous fungal biota of several regions in Turkey have been recently increasing. Almost 1300 species of lichenized fungi and 200 species of lichenicolous fungi are now known from the country (Halıcı 2008; Kocakaya et al. 2015, 2016). Still, there are many areas in Turkey that are insufficiently studied or where no lichenological studies have been conducted.

There are few records of lichenized and lichenicolous fungi from the province of Mersin (Halıcı et al. 2014, Halıcı 2015). During a lichenological exploration in the vicinity of the Akkuyu Nuclear Power Plant (Silifke, Mersin) in the Eastern Mediterranean Region of Turkey, we made an excursion to Beşparmak Island located close to the power plant. On the vertical faces of siliceous rocks in the highest points of the island, we found *Roccella elisabethae* to be very common and frequently infected by *Arthonia follmanniana*; both species are new records for Turkey.

Roccella elisabethae is known from the Atlantic coast of northwest Spain (Galicia) and on islands in the warmer parts of the Atlantic Ocean (Azores,

Canary Islands, Cape Verde Islands, and Madeira; Aptroot & Schumm 2011, Carballal 2013). Previously, *Roccella phycopsis* was the only *Roccella* species known from Turkey. This subtropical genus of lichenized fungi is restricted to coastal habitats and has 32 species worldwide (Tehler et al. 2010; Aptroot & Schumm 2011).

The genus *Arthonia* includes both lichenized and lichenicolous fungi with 41 lichenicolous species previously reported from Turkey (e.g., Halıcı 2008). The holotypes of five lichenicolous *Arthonia* species are from Turkey (Steiner 1899; Candan & Halıcı 2009; Halıcı & Candan 2009, 2011).

Material & methods

The specimens reported here are deposited in Erciyes University Herbarium, Kayseri, Turkey (ERC). Examination was by standard microscopic techniques. Hand-cut sections were studied in water, potassium hydroxide (KOH), and Lugol's solution (I). Measurements were made in water. Ascospores were measured from five different ascomata for each species. Measurements are given as minimum–maximum from *N* measurements. The descriptions presented below are based on the Turkish specimens.

Taxonomy

Roccella elisabethae Tehler, Symb. Bot. Upsal. 34(1): 413. 2004 FIGS 1A,B

THALLUS erect, sometimes pendent; branches terete, slightly flattened, grey to slightly greenish, 1.5–3 cm long, 0.5–0.8 mm wide. Cortex a palisade plectenchyma, C+ red; medulla compact, whitish. SORALIA present, laminal sometimes terminal, C+ red. APOTHECIA and PYCNIDIA absent.

SPECIMEN EXAMINED: **TURKEY**, İÇEL, Gülnar, Beşparmak Island, 36°07′18″N 33°31′58″E, alt. 35 m, on vertical faces of siliceous rocks, 11 April 2012, M.G. Halıcı (ERC AMEKA 0. 077).

COMMENTS—The type specimen of *R. elisabethae* is from the Canary Islands (Tehler et al. 2004), and the species is also known from other Atlantic Ocean islands and the Atlantic coast of Spain (Aptroot & Schumm 2011, Carballal 2013). Our report from the eastern Mediterranean Sea therefore considerably extends its range and *R. elisabethae* should be sought in other parts of the Mediterranean.

Roccella phycopsis is morphologically similar to *R. elisabethae* but differs by its C– soralia and its yellowish medulla (Tehler et al. 2004, Carballal 2013). We note that the Turkish material of *R. elisabethae* has much shorter branches compared with the 2–10 cm cited in the original description of the species, which we attribute to the age of the specimen. Detailed descriptions and illustrations of *R. elisabethae* are provided by Tehler et al. (2004), Aptroot & Schumm (2011), and Carballal (2013).

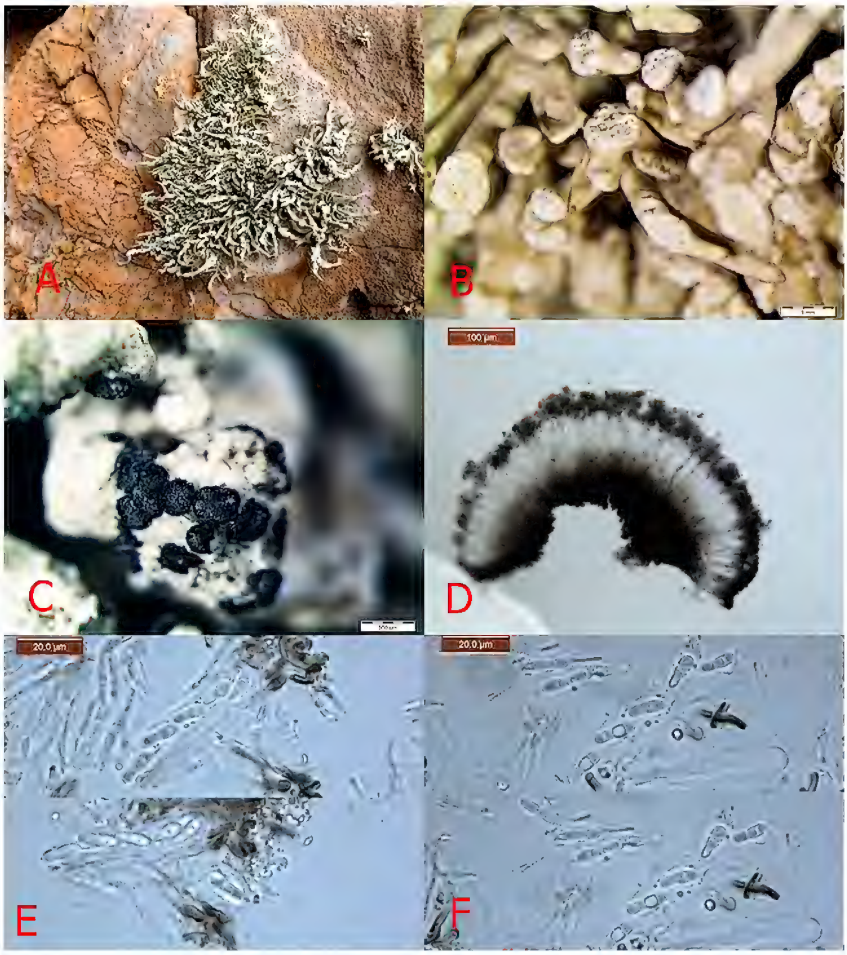


FIG. 1. ***Roccella elisabethae*** (ERC AMEKA 0.077): A, habitus; B, close view of soralia. ***Arthonia follmanniana*** (ERC AMEKA 0.104): C, habitus; D, cross section of ascomata; E, ascospores uniseriately arranged in asci; F, ascospores.

Arthonia follmanniana Diederich, Flechten Follmann: 180. 1995 FIGS 1C-F

ASCOMATA arthonioid, 0.1–0.3 mm diam, black, sometimes with a bluish tinge due to superficial pruina, at first more or less immersed in the thallus of the host lichen, becoming sessile, and mainly on the tips of the branches. EPIHYMENIUM dark olivaceous to almost blackish; hypothecium pale to dark brownish. HYMENIUM colourless, about 25 µm tall; I+ red; K/I+ blue.

Asci 8-spored; ascospores uniseriately arranged in the asci. Ascospores colourless, narrowly soleiform, mostly with a wide and shorter upper cell and narrower and longer lower cell, 2–3-septate, 10–12(–13.5) × 3–4.5(–5) µm (N = 20).

Specimen Examined: **TURKEY**, **İçel**, Gülnar, Beşparmak Island, 36°07′18″N 33°31′58″E, alt. 35 m, on *Roccella elisabethae* on vertical faces of siliceous rocks, 11 April 2012, M.G. Halıcı (ERC AMEKA 0. 104).

Comments—The fungus occurred on the tips of the branches of *Roccella elisabethae*. *Arthonia follmanniana* was described on *R. galapagoensis* in Galapagos Islands (Diederich 1995) but is reported as common on *R. canariensis* and *R. fuciformis* in the Canary Isles (Hafellner 1996). *Roccella elisabethae* is a new host for this species, and the eastern Mediterranean is the third region from which the species is known. A detailed anatomical description of *Arthonia follmanniana*, illustrated with line drawings of the asci and ascospores, is provided by Diederich (1995).

Acknowledgements

The manuscript was reviewed prior to submission by David L Hawksworth (Universidad Complutense de Madrid, Spain) and Sergio Perez-Ortega (Real Jardín Botánico (CSIC), Madrid, Spain). This study was financially supported by FYL-2015-6298 coded project to Erciyes University.

Literature cited

Aptroot A, Schumm F. 2011. Fruticose *Roccellaceae:* an anatomical-microscopical atlas and guide with a worldwide key and further notes on some crustose *Roccellaceae* or similar lichens. 375 pp. Published by the authors and BoD [Books on Demand, available from fschumm@online.de], The Netherlands.

Candan M, Halıcı MG. 2009. Two new lichenicolous *Arthonia* species from Turkey. Mycotaxon 107: 209–213. http://dx.doi.org/10.5248/107.209

Carballal R. 2013. El género "*Roccella*" en la Península Ibérica y las Islas Baleares. Botanica Complutensis 37: 13–20. http://dx.doi.org/10.5209/rev_bocm.2013.v37.42263

Diederich P. 1995. New or interesting lichenicolous fungi VI. *Arthonia follmanniana*, a new species from the Galapagos Islands. 179–182, in: FJA Daniels et al. (eds). Flechten Follmann: contributions to lichenology in honour of Gerhard Follmann. Botanical Institute, University of Cologne.

Hafellner J. 1996. Bemerkenswerte Funde von Flechten und lichenicolen Pilzen auf makaronesischen Inseln V. Über einige Neufunde und zwei neue Arten. Herzogia 12: 133–145.

Halıcı MG. 2008. A key to the lichenicolous *Ascomycota* (including mitosporic fungi) of Turkey. Mycotaxon 104: 253–286.

Halıcı MG. 2015. New records of crustose *Teloschistaceae* and lichenicolous fungi from Turkey. Mycotaxon 130: 769–773. http://dx.doi.org/10.5248/130.769

Halıcı MG, Candan M. 2009. New lichenicolous fungi from Turkey. Nova Hedwigia 88: 483–490. http://dx.doi.org/10.1127/0029-5035/2009/0088-0483

Halıcı MG, Candan M. 2011. *Arthonia anatolica* sp. nov. (*Arthoniaceae*) on *Aspicilia contorta* subsp. *hoffmanniana*, a new lichenicolous species from Turkey. Mycotaxon 116: 335–339. http://dx.doi.org/10.5248/116.335

Halıcı MG, Vondrák J, Demirel R, Ceylan A, Candan M. 2014. *Teloschistaceae* (lichenized ascomycetes) on Turkey II. – Some poorly known taxa, supported by molecular data. Nova Hedwigia 98: 449–458. http://dx.doi.org/10.1127/0029-5035/2013/0163

Kocakaya Z, Halıcı MG, Kocakaya M. 2015. *Phoma candelariellae* sp. nov., a lichenicolous fungus from Turkey. Mycotaxon 130: 1185–1189. http://dx.doi.org/10.5248/130.1185

Kocakaya M, Halıcı MG, Pino-Bodas R. 2016. New or additional cladoniicolous fungi for Turkey. Turkish Journal of Botany 40: 308-311. http://dx.doi.org/10.3906/bot-1502-8

Steiner J. 1899. Lichenes. Denkschriften der Kaiserlichen Akademie der Wissenschaften, Wien. Mathematisch-Naturwissenschaftliche Classe 68: 222–238.

Tehler A, Dahlkid U, Eldenas P, Feige GB. 2004. The phylogeny and taxonomy of Macaronesian, European and Mediterranean *Roccella* (*Roccellaceae*, *Arthoniales*). Symbolae Botanicae Upsalienses 34(1): 405–428.

Tehler A, Irestedt M, Wedin M, Ertz D. 2010. The Old World *Roccella* species outside Europe and Macaronesia: taxonomy, evolution and phylogeny. Systematics and Biodiversity 8: 223–246. http://dx.doi.org/10.1080/14772001003789554

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 645–652

http://dx.doi.org/10.5248/131.645

Diaporthe henanensis sp. nov., an endophytic fungus in *Ziziphus jujuba* from China

Yi Yang [#], Yu-Xia Guo [#], Ya-Kun Zhang, Hai-yan Wu & Meng Zhang *

Henan Agricultural University, 95 Wenhua Road, Zhengzhou, Henan, 450002, China

* Correspondence to: *zm2006@126.com*

Abstract—A species of *Diaporthe* isolated from fruit of *Ziziphus jujuba* during a study of the diversity of endophytic fungi in Zhengzhou, Henan, China, was found to be morphologically and molecularly distinct from known species. This new species, proposed as *Diaporthe henanensis*, differed from other *Diaporthe* species by its pyriform, relatively wide γ-conidia. Analysis of multi-locus DNA sequences (ITS, TUB, HIS) showed that *D. henanensis* was closely related to *D. nobilis, D. neilliae*, and *D. alnea*.

Key words—endophytes, *Phomopsis*, *Ascomycota*, systematics

Introduction

Diaporthe (≡ *Phomopsis*) species are common plant pathogens, endophytes or saprobes (Webber & Gibbs 1984, Carroll 1986, Boddy & Griffith 1989, Rehner & Uecker 1994, Udayanga et al. 2011). In recent years there has been an acceleration in the discovery and naming of new *Diaporthe* species recognized primarily through molecular analyses (Santos & Phillips 2009; Santos et al. 2011; Crous et al. 2011; Udayanga et al. 2012, 2014).

Udayanga et al. (2011) suggested *Diaporthe* species should be identified by a combination of molecular, morphological, cultural, pathological and mating type data. Tan et al. (2013) reported six new *Diaporthe* species from Australia through ITS, TUB, and TEF gene sequence analyses. Huang et al. (2013) reported two *Diaporthe* species based on ITS, EF, TUB, and CAL gene

[#] These authors contributed equally to this study.

Table 1 *Diaporthe* species analysed in this study. Newly deposited sequences are in bold.

Species	Strain	Host	Locality	GenBank accession numbers		
				ITS	TUB	HIS
D. alleghaniensis	CBS495.72	*Betula alleghaniensis*	Canada	KC343007	KC343975	KC343491
D. alnea	CBS146.46	*Alnus* sp.	—	KC343008	KC343976	KC343492
	CBS159.47	*Alnus* sp.	—	KC343009	KC343977	KC343493
D. eres	CBS375.61	*Malus sylvestris*	—	KC343088	KC344056	KC343572
	CBS445.62	*Alliaria officinalis*	Netherlands	KC343091	KC344059	KC343575
D. gardeniae	CBS288.56	*Gardenia florida*	Italy	KC343113	KC344081	KC343597
D. henanensis	HHAUF12291	*Ziziphus jujuba*	China	**KC898258**	**KF600608**	**KF600609**
	HHAUF12292	*Ziziphus jujuba*	China	**KC898259**	**KF600610**	**KF600611**
D. juglandina	CBS121004	*Juglans* sp.	USA	KC343134	KC344102	KC343616
D. neilliae	CBS144.27	*Spiraea* sp.	—	KC343144	KC344112	KC343628
D. nobilis	CBS116953	*Pyrus pyrifolia*	New Zealand	KC343147	KC344115	KC343631
	CBS333.89	*Hedera helix*	Yugoslavia	KC343152	KC344120	KC343636
D. vaccinii	CBS122115	*Vaccinium corymbosum*	USA	KC343226	KC344194	KC343710
	CBS122114	*Vaccinium corymbosum*	USA	KC343225	KC344193	KC343709

sequence analyses. Gomes et al. (2013) investigated 243 isolates of *Diaporthe*, divided them into 95 species using multi-locus DNA sequence data (incl. ITS, HIS, TUB, CAL, TEF1), and concluded that future species descriptions should include at least ITS as well as HIS or TUB sequence data.

Ziziphus jujuba Mill. (*Rhamnaceae*) is a small deciduous tree grown in China for its edible fruit. During a study of the diversity of endophytic fungi in Zhengzhou, Henan, China, a fungus regularly isolated from fruit of *Z. jujuba* was shown to represent a novel species of *Diaporthe*, which is described here as *Diaporthe henanensis*.

Materials & methods

Isolates, media, and culturing

Healthy fruit of *Ziziphus jujuba* was collected near Zhengzhou, Henan Province, China. Tissue pieces of about 3 mm^3 were treated with 75% ethanol for 30 s, surface disinfected in 3% sodium hypochlorite for 3 min, rinsed with sterile distilled water, then placed on potato carrot agar (PCA) plates at 25 °C for one week. Young colonies were transferred to potato dextrose agar (PDA) plates and kept at room temperature under alternating light and dark periods (Xie et al. 2010) for conidium production. Morphological characteristics of conidia and conidiophores were microscopically observed after 10 d.

The type specimen was deposited in the Herbarium Mycologicum Academae Sinicae, Beijing, China (HMAS), and cultures were deposited in China General Microbiological Culture Collection Centre, Beijing, China (CGMCC) and in the Herbarium Henan Agricultural University: Fungi, Zhengzhou, China (HHAUF).

DNA extraction, polymerase chain reaction, and sequencing

Total DNA was extracted from mycelium scraped from the surface of a PDA plate with the Cell Genomic DNA Isolation Kit (LifeFeng, Shanghai, China) following the manufacturer's instructions. The primers ITS1 and ITS4 (White et al. 1990) were used to amplify the ITS1-5.8S-ITS2 rDNA region (ITS) (Luo & Mitchell 2002). The primers T1 (O'Donnell & Cigelnik
1997) and bt2b (Glass & Donaldson 1995) were used to amplify part of the tubulin gene (TUB). The primers CYLH3F (Crous et al. 2004) and H3-1b (Glass & Donaldson 1995) were used to amplify part of the histone H3 gene (HIS). PCR was carried out using an Eppendorf PCR thermal cycler (Germany). The reaction products were analyzed by electrophoresis on a 1.0% agarose gel in tris-acetate-EDTA (TAE) buffer with ethidium bromide (0.1 mg/mL) and visualized under UV light (Xie et al. 2010). The PCR products were sequenced by Shanghai Sangon Biological Engineering Technology & Service Co., Ltd., China.

The ITS sequences were initially aligned with published ITS sequence data of *Diaporthe* spp. obtained from the NCBI using ClustalW in MEGA ver. 5.2 (Tamura et al. 2011). *Diaporthella corylina* was selected as the outgroup taxon. A neighbor–joining (NJ)

analysis using the Kimura-2 parameter with Gamma distribution was applied to nine similar species and the closest phylogenetic neighbours were selected for a combined analysis using ITS, TUB and HIS genes (Table 1). A Maximum likelihood tree using the combined dataset was generated in MEGA 5.2 using the Tamura-Nei substitution model with Gamma distribution. Bootstrap support values with 1000 replications were calculated for tree branches (Tan et al. 2013).

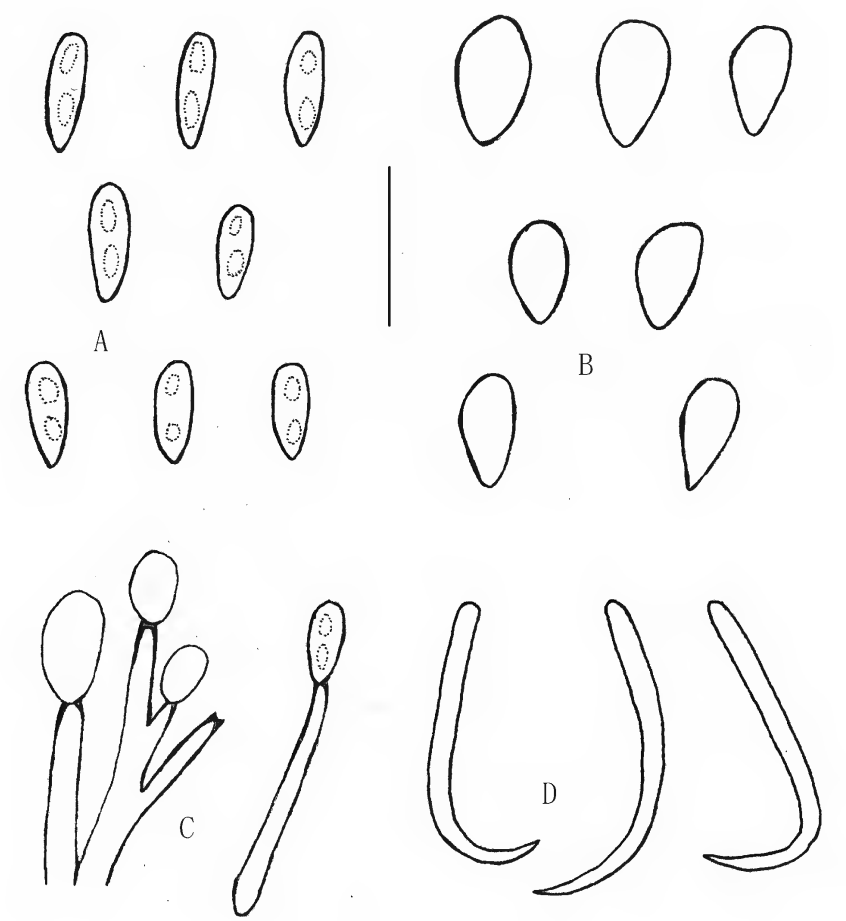


Fig. 1 *Diaporthe henanensis* on PDA.
A. α-conidia; B. γ-conidia; C. Conidiophores; D. β-conidia.
Scale bar = 10 μm.

Taxonomy

Diaporthe henanensis Yi Yang, H.Y. Wu & Meng Zhang, **sp. nov.** FIG.1

MycoBank MB 804356

Differs from all other *Diaporthe* spp. by its γ-conidia that are broadly pyriform and by its multi-locus gene sequence data.

Type: China, Henan Province, Zhengzhou, from healthy fruit of *Ziziphus jujuba*, 26 Sep. 2012, coll. Y. Yang (**Holotype**, HMAS246233 [dried culture]; ex-type strain, CGMCC3.17639 = HHAUF12291; GenBank KC898258, KF600608, KF600609).

Etymology: Named for the collection locality.

Pycnidia scattered in PDA, dark brown to black, globose to subglobose, 800–1700 μm diam. Conidiophores subcylindrical, hyaline, smooth, simple or branched, 14–18 × 1.5–2.0 μm. Conidiogenous cells phialidic, cylindrical, tapering towards the apex, with periclinal thickening. Collarettes inconspicuous. Three kinds of conidia were produced: α-conidia, unicellular, hyaline elliptical or clavate, one end obtuse, the other acute, 2-guttulate, 5–8 × 2–3 μm; β-conidia hyaline, aseptate, without guttules, filiform, curved or hamate, with obtuse ends, 15.5–31 × 0.8–1.5 μm; γ-conidia, pyriform, 5–7 × 3.5–5.0 μm.

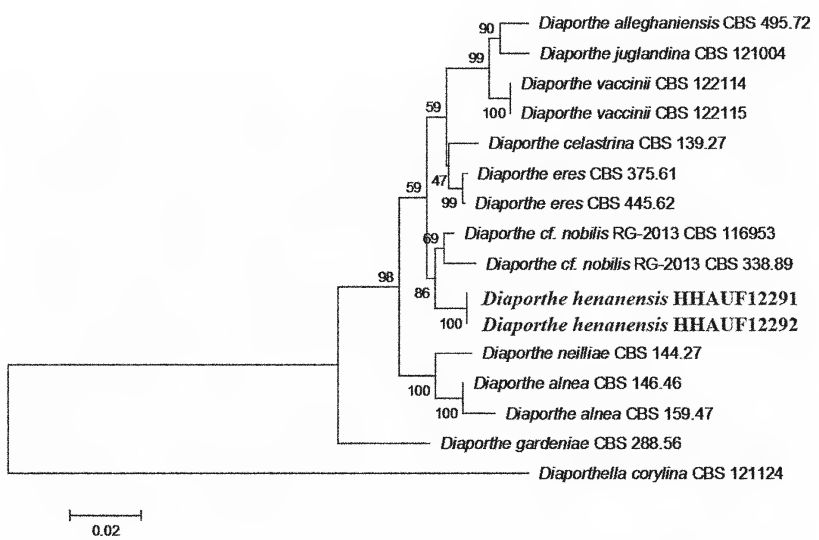


FIG. 2 Maximum likelihood tree inferred from combined analysis of three genes (ITS, TUB, HIS). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) is shown next to the branches. The tree was rooted to *Diaporthella corylina*. The newly sequenced strains of our new species are in bold..

Additional material examined: **CHINA**, **Henan Province**, Zhengzhou, from healthy fruit of *Ziziphus jujuba*, 26 Sep. 2012, coll. Y. Yang (HHAUF12292; GenBank KC898259, KF600610, KF600611).

Discussion

All other *Diaporthe* species differ from *D. henanensis* either by lacking γ-conidia or by producing γ-conidia that are not broadly pyriform (Crous et al. 2012, Gomes 2013, Uecker 1988, Qi et al. 2007). The initial ITS sequence data support *D. nobilis*, *D. neilliae*, *D. alnea*, *D. juglandina*, *D. eres*, *D. gardeniae*, *D. alleghaniensis*, and *D. vaccinii* as the most closely related phylogenetic neighbours. The two isolates clustered with each other in a single clade with 100% bootstrap support in the ML tree inferred from analysis of three genes (ITS, TUB, HIS; Fig. 2).

Many species of *Diaporthe* are known to be endophytic on a range of host plants (Murali et al. 2006, Chaeprasert et al. 2010, Rocha et al. 2011, Sun et al. 2011). In this study, *D. henanensis* was isolated and described as new based on its distinctive morphology (broadly pyriform γ-conidia) and multi-locus gene sequence data (ITS, TUB, HIS).

Acknowledgments

We thank Dr R. F. Castañeda Ruiz, Instituto de Investigaciones Fundamentales en Agricultura Tropical (INIFAT), Cuba and Dr R. G. Shivas (Queensland Plant Pathology Herbarium, Australia) for pre-submission review. This project was supported by the National Natural Science Foundation of China (31171804 and 30970016) and Program for Science & Technology Innovation Talents in Universities of Henan Province (13HASTIT007).

Literature cited

Boddy L, Griffith GS. 1989. Role of endophytes and latent invasion in the development of decay communities in sapwood of angiospermous trees. Sydowia 41: 41–73.

Carroll GC. 1986. The biology of endophytism in plants with particular reference to woody perennials. 205–222, in: NJ Fokkema, J van den Heuvel (eds). Microbiology of the Phyllosphere. Cambridge University Press, Cambridge.

Chaeprasert S, Piapukiew J, Whalley AJS, Sihanonth P. 2010. Endophytic fungi from mangrove plant species of Thailand: their antimicrobial and anticancer potentials. Botanica Marina 53: 555–564. http://dx.doi.org/10.1515/bot.2010.074

Crous PW, Groenewald JZ, Risede J-M, Hywel-Jones NL. 2004. *Calonectria* species and their *Cylindrocladium* anamorphs: species with sphaeropedunculate vesicles. Studies in Mycology 50: 415–430.

Crous PW, Groenewald JZ, Shivas RG, Edwards J, Seifert KA, et al. 2011. Fungal Planet description sheets: 69–91. Persoonia 26: 108–156. http://dx.doi.org/10.3767/003158511X581723

Crous PW, Summerell BA, Shivas RG, et al . 2012. Fungal Planet description sheets: 107–127. Persoonia 28: 138–182. http://dx.doi.org/10.3767/003158512X652633

Glass NL, Donaldson GC. 1995. Development of primer sets designed for use with the PCR to amplify conserved genes from filamentous ascomycetes. Applied and Environmental Microbiology 61: 1323–1330. http://aem.asm.org/content/61/4/1323

Gomes RR, Glienke C, Videira SIR, Lombard L, Groenewald JZ, Crous PW. 2013. *Diaporthe*: a genus of endophytic, saprobic and plant pathogenic fungi. Persoonia 31: 1–41. http://dx.doi.org/10.3767/003158513X666844

Luo GZ, Mitchell TG. 2002. Rapid identification of pathogenic fungi directly from cultures by using multiplex PCR. Journal of Clinical Microbiology 40: 2860–2865. http://dx.doi.org/10.1128/JCM.40.8.2860-2865.2002

Murali TS, Suryanarayanan TS, Geeta R. 2006. Endophytic *Phomopsis* species: host range and implications for diversity estimates. Canadian Journal of Microbiology 52: 673–680. http://dx.doi.org/10.1139/W06-020

O'Donnell K, Cigelnik E. 1997. Two divergent intragenomic rDNA ITS2 types within a monophyletic lineage of the fungus *Fusarium* are nonorthologous. Molecular Phylogenetics and Evolution 7: 103–116

Qi PK, Jiang ZD, Xiang MM. 2007. Flora Fungorum Sinicorum Vol. 34 Phomopsis. Science Press, Beijing. 185 p.

Rehner SA, Uecker FA. 1994. Nuclear ribosomal internal transcribed spacer phylogeny and host diversity in the coelomycete *Phomopsis*. Canadian Journal of Botany 72: 1666–1674. http://dx.doi.org/10.1139/b94-204

Rocha ACS, Garcia D, Uetanabaro APT, Carneiro RTO, Araújo IS, Mattos CRR, Góes-Neto A. 2011. Foliar endophytic fungi from *Hevea brasiliensis* and their antagonism on *Microcyclus ulei*. Fungal Diversity. 47: 75–84. http://dx.doi.org/10.1007/s13225-010-0044-2

Santos JM, Phillips AJL. 2009. Resolving the complex of *Diaporthe* (*Phomopsis*) species occurring on *Foeniculum vulgare* in Portugal. Fungal Diversity 34: 111–125.

Santos JM, Vrandečić K, Ćosić J, Duvnjak T, Phillips AJL. 2011. Resolving the *Diaporthe* species occurring on soybean in Croatia. Persoonia 27: 9–19. http://dx.doi.org/10.3767/003158511X603719

Sun X, Guo LD, Hyde KD. 2011. Community composition of endophytic fungi in Acer truncatum and their role in decomposition. Fungal Diversity. 47: 85–95. http://dx.doi.org/10.1007/s13225-010-0086-5

Tamura K, Peterson D, Peterson N, Stecher G, Nei M, Kumar G. 2011. MEGA5: Molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. Molecular Biology Evolution 28:2731–2739. http://dx.doi.org/10.1093/molbev/msr121

Tan YP, Edwards J, Grice KRE, Shivas RG. 2013. Molecular phylogenetic analysis reveals six new species of *Diaporthe* from Australia. Fungal Diversity 61: 251–260. http://dx.doi.org/10.1007/s13225-013-0242-9

Udayanga D, Liu XZ, McKenzie EHC, Chukeatirote E, Bahkali AHA, Hyde KD. 2011. The genus *Phomopsis*: biology, applications, species concepts and names of common pathogens. Fungal Diversity 50: 189–225.

Udayanga D, Liu XZ, Crous PW, McKenzie EHC, Chukeatirote E, Hyde KD. 2012. A multi-locus phylogenetic evaluation of *Diaporthe* (*Phomopsis*). Fungal Diversity 56: 157–171. http://dx.doi.org/10.1007/s13225-012-0190-9

Udayanga D, Castlebury LA., Rossman AY, Chukeatirote E, Hyde KD. 2014. Insights into the genus *Diaporthe*: phylogenetic species delimitation in the *D. eres* species complex. Fungal Diversity 67: 203–229. http://dx.doi.org/10.1007/s13225-014-0297-2

Uecker FA. 1988. A world list of *Phomopsis* names with notes on nomenclature, morphology and biology. Mycologia Memoir 13. 231 p.

Webber J F, Gibbs JN. 1984. Colonization of elm bark by *Phomopsis oblonga*. Transactions of the British Mycological Society 82(2): 348–352. http://dx.doi.org/10.1016/S0007-1536(84)80083-2

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis et al. (eds). PCR protocols: a guide to methods and applications. San Diego, CA. Academic Press. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

Xie L, Huang SL, Cen ZL. 2010. First report of *Botryosphaeria dothidea* causing sweet osmanthus leaf dieback in China. Agricultural Sciences in China 9: 847–853. http://dx.doi.org/10.1016/S1671-2927(09)60163-2

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 653–661

http://dx.doi.org/10.5248/131.653

Notes on rust fungi in China 1. Autoecious life cycle of *Puccinia tatarinovii* on *Prenanthes*

Jing-Xin Ji [1], Qi Wang [1], Zhuang Li [2], Yu Li [1] & Makoto Kakishima [1,3*]

[1] *Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, Changchun, Jilin 130118 China*

[2] *College of Plant Protection, Shandong Agricultural University, Tai'an 271000 China*

[3] *University of Tsukuba, Tsukuba, Ibaraki 305-8572 Japan*

* Correspondence to: *kakishima.makoto.ga@u.tsukuba.ac.jp*

Abstract—During investigations of rust fungi in Jilin Province, northeast China, aecial and telial stages were observed on *Prenanthes tatarinowii* in different seasons. The telial stage was identified as *Puccinia tatarinovii* by morphological observations. Life cycle connection between aecial and telial stages was clarified by field observations and molecular data. Morphology of the spermogonial and aecial stages is described based on specimens connected to telial stage. Lectotype and epitype specimens are designated.

Key words—aecial stage, ecology, morphology, spermogonium, taxonomy

Introduction

Puccinia tatarinovii was described by Tranzschel (1939) based on four specimens on *Prenanthes tatarinowii* Maxim. (*Compositae*) collected in the Far East of Russia and northeast of China (Manchuria). Although aecial, uredinial and telial stages were reported in this description no morphological characters of the aecial stage were described, and no type specimen was designated. *Puccinia tatarinovii* is morphologically similar to *Pu. orbicula* Peck & Clinton recorded on *Prenanthes* spp., although verrucae on the surface of its teliospores are larger than those of *Pu. orbicula* (Tranzschel 1939, Ito 1950, Hiratsuka et al. 1992, Zhuang 2003). In China, telia of a rust fungus on *Pr. tatarinowii* were collected at Longtan mountain, Jilin, Jilin Province, northeast China in September 1923 and were reported as *Puccinia prenanthis-racemosae* P. Syd. & Syd. [= *Pu. orbicula*] (Miura 1928). Later, the rust specimens on *Pr. tatarinowii* were mostly treated as *Pu. tatarinovii* (Ito 1950, Tai 1979, Wei & Wang 1986,

Zhuang 2003). However, they were sometimes reported as *Pu. orbicula* because they are morphologically similar and their host plants are in the same genus, *Prenanthes* (Tai 1979). Both rust species have also been reported to have an autoecious life cycle (Tranzschel 1939, Ito 1950, Cummins 1978, Zhuang 2003), but spermogonial and aecial stages of *Pu. tatarinovii* have not been clearly distinguished, and they have been confused with those of *Pu. orbicula* as these stages have not been found on the same plants at the same time. This is also largely because no morphological information has been recorded for the aecia of *Pu. tatarinovii,* and there is no record of aecial specimens in China, though many specimens of this species have been collected on *Pr. tatarinowii* and *Pr. macrophylla* Franch. from various areas of China (Wei & Wang 1986, Zhuang 2003). Azbukina (2005) described spermogonial and aecial stages on *Pr. tatarinowii*, but connection between aecial and telial stages of this species was not demonstrated.

During our investigation of rust fungi in Jilin Province, China, we found aecial (Fig. 1A) and telial stages (Fig. 2A) on *Pr. tatarinowii* at the same place in Jilin city, although they were observed at different times of the year. Therefore, we suspected that these stages were produced by the same species. We carried out morphological observations of these stages and also molecular analyses to confirm the connection between the aecial and telial stages. We report here the autoecious life cycle of *Pu. tatarinovii* and describe its morphology based on these specimens. We also designate an epitype specimen for this species.

Materials & methods

Specimens

Aecial and telial specimens on *Pr. tatarinowii* were collected in Hongyegu, Jiaohe, Jilin city, Jilin Province, China (43°42′13″N 127°04′18″E, alt. 537 m) in June and September, 2015, and used for morphological observations and molecular analysis. Specimens identified as *Pu. tatarinovii* and deposited in the Fungal Herbarium, Institute of Microbiology, Academia Sinica (HMAS), were borrowed for comparative morphology. Dry specimens used in the experiments were deposited in the Herbarium of Mycology, Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, China (HMJAU).

Morphological observations

Light microscopy (LM) was used to examine morphological characters including the size and shape of sori and spores. Spores or thin-sections of sori from specimens were mounted in a drop of lactophenol solution on glass slides for LM. Approximately 50 spores from each specimen were randomly chosen and the length, width, and wall thickness of spores were measured using Leica LAS X software attached to a Leica DM2000 microscope (Leica, Germany).

The surface features of spores were examined by scanning electron microscopy (SEM). For SEM, samples obtained from dry specimens were attached to specimen

holders by double-sided adhesive tape and coated with platinum-palladium using a Hitachi MC1000 Ion Sputter Coater and examined with a Hitachi SU8010 SEM operated at 5 kV.

DNA extraction and sequencing of rDNA-ITS regions

The total genomic DNA was extracted from about 200 spores obtained from a single sorus (aecidium or telium) on specimens. Spores were crushed between two sterilized glass slides and suspended in 30 µl extraction buffer [10mM Tris-HCl pH 8.3, 1.5 mM $MgCl_2$, 50 mM KCl, 0.01% sodium dodecyl sulfate (SDS), 0.01% Proteinase K], and the suspensions were incubated at 37°C for 1 hour and 95°C for 10 min, followed by a 4°C soak (Suyama et al. 1996, Virtudazo et al. 2001). From the crude extract, 5–7 µl samples were used directly for each polymerase chain reaction (PCR). The rDNA-ITS region was amplified using primers ITS1F (5′-CTTGGTCATTTAGAGGAAGTAA-3′) (Gardes & Bruns 1993) and ITS4 (5′-TCCTCCGCTTATTGATATGC-3′) (White et al. 1990). The PCR amplifications were performed in 50 µl of mixture containing 5 µl of template DNA, 200 µl of each primer, 25 µl of Premix Taq™ (TaKaRa Taq™ Version 2.0 plus dye) (TaKaRa, Tokyo, Japan), and 18 µl of ddH_2O. Cycling conditions for amplification consisted of 94°C for 5 min, followed by 35 cycles of denaturation at 94°C for 30 s, annealing at 45°C for 30 s and extension at 72°C for 1 min, and a final extension at 72°C for 10 min. PCR products were separated on 1% agarose gels that pulsed Nucleic Acid Stain (Beijing Dinggou Changsheng Biotechnology Co. Ltd.) and purified using the TaKaRa MiniBEST Agarose Gel DNA Exaction Kit Ver.4.0 (TaKaRa, Tokyo, Japan). Purified PCR products were cloned in pEASY®-T1 Cloning Vector (Transgene Biotech, Beijing, China) and then transferred into *Trans*1-T1 phage, resistant chemically competent cell according to the manufacturer's instructions. The positive clones were sequenced by Sangon Biotech Co., Shanghai, China.

Sequence similarity (%) of rDNA-ITS regions among specimens was calculated by the NCBI program (NCBI, USA).

Results & discussion

Life cycle

Sequences obtained from specimens of aecial stage with spermogonial (HMJAU8206) and telial stages (HMJAU8204) were used for analysis and these data were deposited at GenBank. However, DNA could not be extracted from spores obtained from the HMAS specimens. Chemical treatment of specimens in the herbarium may affect their DNA. Sequence similarity of rDNA-ITS regions (689 bp in length) between aecial and telial specimens was 100%. Therefore, both specimens are genetically identical and life cycle connection between aecial and telial stages on *Pr. tatarinowii* was confirmed. In the Jilin Province field observation, the uredinial stage was not found, although a few urediniospores were recognized in most specimens deposited in HMAS. We suspect that production of the uredinial stage is affected by climatic conditions.

From the results of DNA analysis and specimen observation, the autoecious macrocyclic life cycle of *Pr. tatarinowii* was clarified. Inoculations

of plants with spores are best for clarifying life cycles, but collections of the plant are restricted on the mountain because of nature conservation and its transplantation to distant places is difficult. Therefore, we used DNA analysis instead of inoculations and confirmed that sequence analysis is a useful tool to clarifying a life cycle. Tranzschel (1939) and Azbukina (2005) reported aecia, but provided no information that these aecia were observed on the same host plants that produced telia. Therefore, our results provide the first evidence of the complete life cycle in this species.

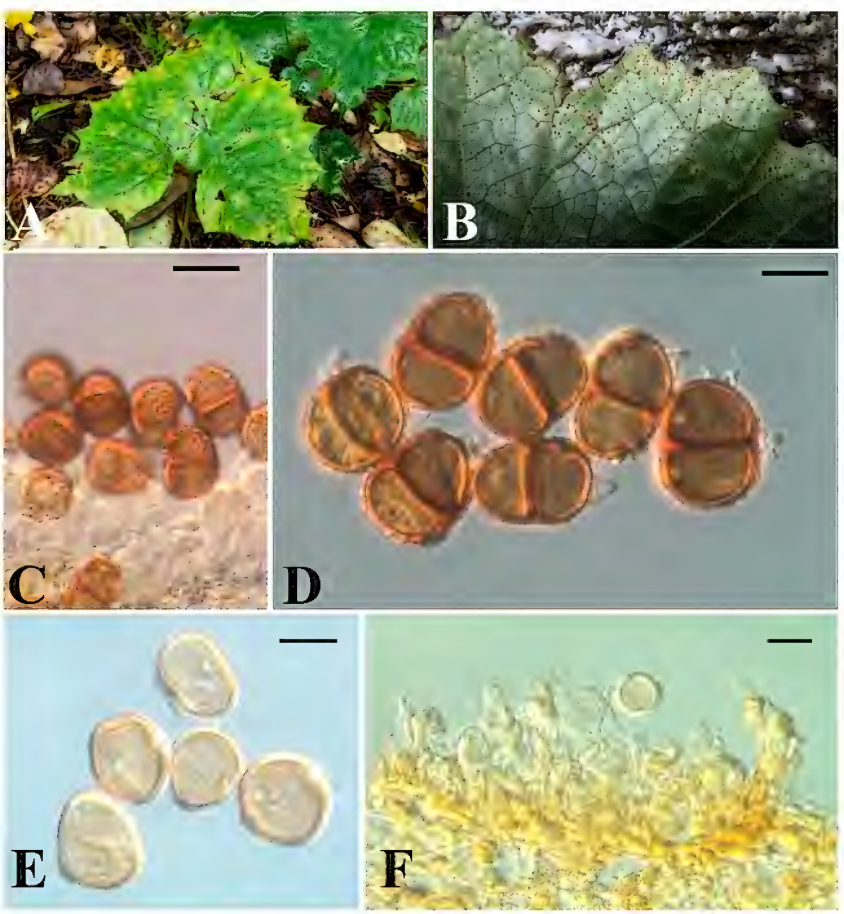


Figure 2. Uredinial and telial stages of *Puccinia tatarinovii* on *Prenanthes tatarinowii*: A, B. Telia on the upper (A) and under (B) leaf surface of *Pr. tatarinowii*; D. Vertical section of a telium; D. Teliospores; E. Urediniospores; F. Vertical section of an uredinium. Scale bars: C = 40 μm; D, F = 30 μm; E = 20 μm.

Morphology

Based on observations with specimens collected in Jilin Province (HMJAU) and specimens borrowed from HMAS, an updated description of *Pu. tatarinovii* is provided.

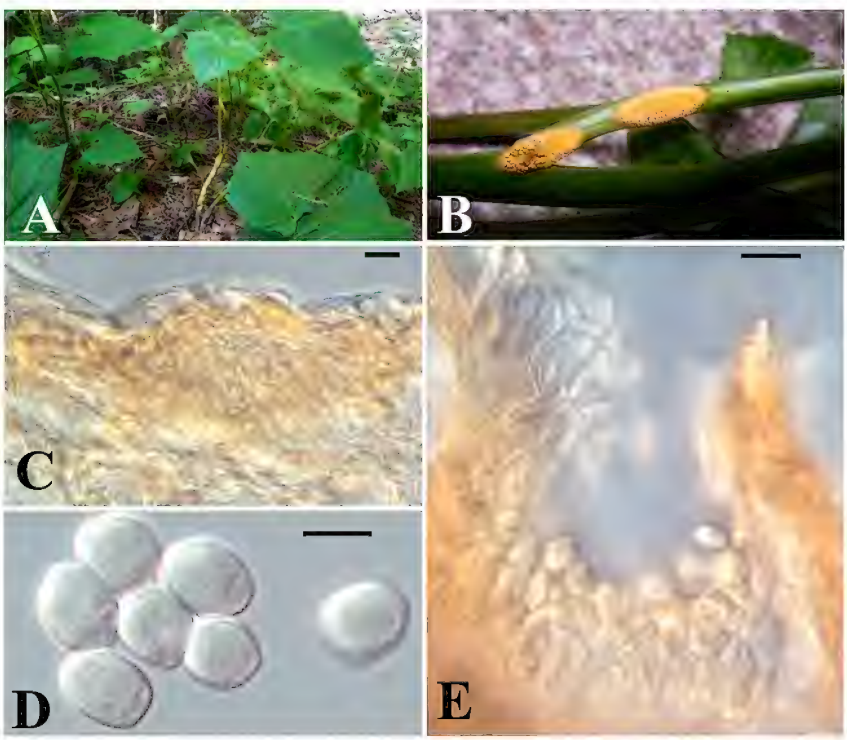


FIGURE 1. Spermogonial and aecial stages of *Puccinia tatarinovii* on *Prenanthes tatarinowii*: A, B. *Pr. tatarinowii* producing aecia in June 2015; C. Aecia produced on the stem; D. Vertical section of a spermogonium (Type 4); D. Aeciospores; E. Vertical section of an aecium. Scale bars: C, D = 20 μm; E = 30 μm.

Puccinia tatarinovii Kom. & Tranzschel, Consp. Ured. URSS: 393, 1939. FIGS 1–3

TYPE: Russia, Russian Far East, Primorsky Territory, near Vladivostok, III on *Prenanthes tatarinowii,* 10 Sep. 1913, leg. N. Djukina (**Lectotype designated here**, LE44326). China, Jilin, 0, I on *Pr. tatarinowii,* 24 June 2015, leg. M. Kakishima & J.X. Ji (**Epitype designated here**, HMJAU8206; GenBank KU955596).

Spermogonia subepidermal, Group V (type 4). Aecia mainly caulicolous, sometime hypophyllous, in small roundish groups or along veins, short, cupulate; peridia yellowish white, the margin revolute, lacerate, peridial cells

polygonal or rhomboid, the outer walls striate, the inner walls verrucose, thin; aeciospores angular-globose or ellipsoid, yellowish, 13.9–22.4 × 11.4–18.0 µm (av. 17.1 × 15.2 µm), walls hyaline and verrucose, 0.3–1.6 µm (av. 0.9 µm) thick. Uredinia amphigenous, scattered, orange-yellow, globoid; urediniospores globoid or ellipsoid, 19.0–28.6 × 17.6–25.3 µm (av. 24.6 × 22.5 µm), walls uniformly thick 1.0–3.0 µm (av. 1.8 µm), echinulate. Telia mainly hypophyllous or rarely epiphyllous, especially in heavy infections, subepidermal, erumpent when mature, brown to dark brown; teliospores 2-celled, borne singly on pedicels, fusiform or oblong, sub-rotund or narrowed above, more or less constricted at the septum 25.8–44.3 × 22–32.2 µm (av. 34.1 × 23.8 µm), walls pigmented, yellowish-brown, 0.5–3.3 µm (av. 1.9 µm) thick, largely verrucose; pedicels up to 5.2 µm long.

Hosts & distribution — On *Prenanthes tatarinowii*: **Russia**: Primorsky Territory; **China**: Jilin, Hubei, Beijing, Hebei, Shaanxi, Sichuan (Tranzschel 1939, Zhuang 2003, Azbukina 2005). On *Pr. macrophylla*: **China**: Sichuan (Zhuang 2003).

Additional specimens examined —

0, I on *Pr. tatarinowii*: CHINA, Sichuan, 17 Sep. 1989 (HMAS63916); **Hubei**, 19 Aug. 1984 (HMAS50409); 27 Aug. 1984 (HMAS50414).

II on *Pr. tatarinowii*: CHINA, Beijing, 8 June 1957 (HMAS55746); **Hubei**, 4 July 1984 (HMAS57292); **Shaanxi**, 9 July 1988 (HMAS64179, HMAS64181).

II, III on *Pr. tatarinowii*: CHINA, Hubei, 18 Aug. 1984 (HMAS50410); 19 Aug. 1984 (HMAS50411); 27 Aug. 1984 (HMAS50413); 29 Aug. 1984 (HMAS57289).

III on *Pr. tatarinowii*: CHINA, Jilin, 2 Oct. 2015 (HMJAU8201); 23 Sep. 2015 (HMJAU8202, HMJAU8203); 21 Sep. 2015 (HMJAU8204; GenBank KU950447); 15 Sep. 2013 (HMJAU8207); **Hubei**, 27 Aug. 1984 (HMAS50412); **Hebei**, 1936 (HMAS06987); Aug. 1936 (HMAS12027); **Beijing**, 3 Sep. 1957 (HMAS65837); 1 Aug. 1957 (HMAS65838); 5 Oct. 1957 (HMAS25656); **Sichuan**, 23 Sep. 1989 (HMAS63915, HMAS63914, HMAS63931, HMAS63932, HMAS63933); 17 Sep. 1989 (HMAS63934, HMAS63935, HMAS63936).

III on *Pr. macrophylla*: CHINA, Sichuan, 13 Oct. 1989 (HMAS63917); 14 Oct. 1989 (HMAS63918, HMAS63919); 17 Sep. 1989 (HMAS63920, HMAS63921).

The morphological characters of uredinial and telial stages of *Pu. tatarinovii* on *Pr. tatarinowii* were similar to the descriptions of *Pu. tatarinovii* reported by Tranzschel (1939), Ito (1950), Wei & Wang (1986), Zhuang (2003), and Azbukina (2005), although there is some variation in teliospore size among these descriptions. Uredinial and telial morphologies of *Pu. tatarinovii* are quite similar to *Pu. orbicula* except for the surface structure of teliospores (Tranzschel 1939, Ito 1950, Hiratsuka et al. 1992, Zhuang 2003). Verrucae on teliospores of *Pu. tatarinovii* are larger than those of *Pu. orbicula* as reported by Tranzschel (1939) and Zhuang (2003). Therefore, verrucal size is an important character for distinguishing these species. Our observations of the aecial stage of

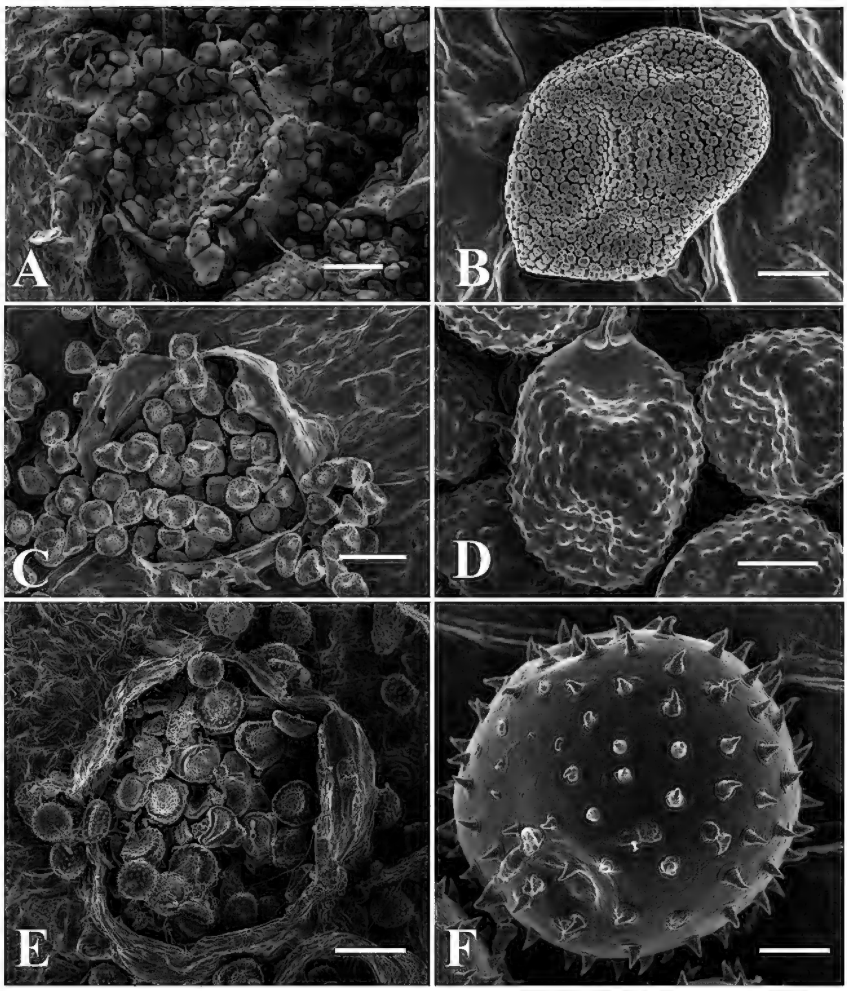


FIGURE 3. Aecial, uredinial, and telial stages of *Puccinia tatarinovii* on *Prenanthes tatarinowii* observed with SEM: A. Aecidium; B. Aeciospore with verrucose surface; C. Telium; D. Teliospores with large verrucae; E. Uredinium; F. Urediniospore with echinulate surface. Scale bars: A = 200 μm; B = 0.5 μm; C = 100 μm; D = 20 μm; E = 50 μm; F = 8 μm.

Pu. tatarinovii showed that its aeciospores are smaller than those of *Pu. orbicula* (23–30 × 18–22 μm) as also reported by Cummins (1978). Our observations are also similar to the description of Azbukina (2005). Therefore, size of aeciospores is an important character to recognize species. *Puccinia tatarinovii* is recorded on only two host plants, *Pr. tatarinowii* and *Pr. macrophylla*, and

distributed only in China and the Russian Far East (Tranzschel 1939, Zhuang 2003, Azbukina 2005), whereas *Pu. orbicula* is widely distributed on species of *Prenanthes* (Cummins 1978, Azbukina 1984, 2005, Hiratsuka et al. 1992).

Tranzschel (1939) did not designate a type specimen of *Pu. tatarinovii* although he listed four specimens in his description. Petrak (1950: 92) also did not indicate the type for this species. Later, Azbukina (2005) selected a lectotype from these specimens but did not designate it according to the requirements of ICN Art. 7.10 (McNeill et al. 2012). Therefore, we checked specimens deposited in LE and selected as lectotype the specimen which Tranzschel separated from others as a type (personal communication from LE). Additionally, we designate a spermogonial and aecial specimen as an epitype, because aecial morphology is important to recognize the species.

Acknowledgments

This work was financed by the Science and Technique Foundation of Education Department of Jilin Province (20130206073NY) and Recruitment Program of Foreign Experts (WQ20122200064). We wish to thank Dr. E.H.C. McKenzie (Landcare Research, Auckland, New Zealand) and Dr. C.M. Denchev (Bulgarian Academy of Sciences, Sofia, Bulgaria) for critical reading of the manuscript and suggestions. We express our thanks to Dr. O. Morozova (Komarov Botanical Institute, St. Petersburg, Russia (LE)) for the examination of specimens. We also thank Dr. Y.-J. Yao, curator of the Fungal Herbarium (Institute of Microbiology, Academia Sinica, Beijing, HAMS) for loan of specimens. We also thank Dr. B. Qu (Shenyang Agricultural University) for identification of plant specimens.

Literature cited

Azbukina ZM. 1984. The manual of rust fungi in Soviet Far East. Nauka, Moscow.

Azbukina ZM. 2005. Rust fungi. Cryptogamic plants, fungi and mosses of the Russian Far East, vol. 5. Dalnauka, Vladivostok. 616 p. (In Russian)

Cummins GB. 1978. Rust fungi on legumes and composites in North America. University of Arizona Press, Tucson.

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes: application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. http://dx.doi.org/10.1111/j.1365-294X.1993.tb00005.x

Hiratsuka N, Sato S, Katsuya K, Kakishima M, Hiratsuka Y, Kaneko S, Ono Y, Sato T, Harada Y, Hiratsuka T, Nakayama K. 1992. The rust flora of Japan. Tsukuba-shuppankai, Tsukuba.

Ito S. 1950. Mycological flora of Japan, vol. 2, no 3. Yokendo, Tokyo.

McNeill J, Barrie FR, Buck WR, Demoulin V, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Marhold K, Prado J, Prud'homme van Reine WF, Smith GF, Wiersema JH, Turland NJ. 2012. International Code of Nomenclature for algae, fungi, and plants (Melbourne Code). Regnum Vegetabile 154. http://www.iapt-taxon.org/nomen/main.php

Miura M. 1928. Flora of Manchuria and east Mongolia III. Cryptogams, Fungi. Minamimanshutetsudo, Dalian.

Petrak F. 1950. List of new species and varieties of fungi, new combinations and new names published 1936–1939. Petrak's Lists 8. 117 p.

Suyama Y, Kawamuro K, Kinoshita I, Yoshimura K, Tsumura Y, Takahara H. 1996. DNA sequence from a fossil pollen of *Abies* spp. from Pleistocene peat. Genes & Genetic Systems 71: 145–149. http://dx.doi.org/10.1266/ggs.71.145

Tai FL. 1979. Sylloge Fungorum Sinicorum. Science Press, Peking.

Tranzschel W. 1939. Conspectus uredinalium URSS. Academy of Sciences USSR, Moscow. 426 p.

Virtudazo EV, Nakamura H, Kakishima M. 2001. Phylogenetic analysis of sugarcane rusts based on sequences of ITS, 5.8 S rDNA and D1/D2 regions of LSU rDNA. Journal of General Plant Pathology 67: 28–36. http://dx.doi.org/10.1007/PL00012983

Wei SX, Wang YC. 1986.Taxonomic studies of *Puccinia* on *Compositae* in China. Acta Mycologica Sinica Suppl. 1: 185–226.

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis et al. (eds.). PCR protocols: a guide to methods and applications. San Diego, CA. Academic Press. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

Zhuang JY. 2003. Flora Fungorum Sinicorum vol. 19, *Uredinales* (II). Science Press, Beijing.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 663–670

http://dx.doi.org/10.5248/131.663

Gymnopus ramulicola sp. nov., a pinkish species from southern China

Shu-Fang Deng [1,2], Tai-Hui Li [1,2*], Zi-De Jiang [1] & Bin Song [2]

[1] *Department of Plant Pathology/Guangdong Province Key Laboratory of Microbial Signals & Disease Control, South China Agricultural University, Guangzhou 510642, China*

[2] *State Key Laboratory of Applied Microbiology Southern China, Guangdong Provincial Key Laboratory of Microbial Culture Collection & Application, Guangdong Institute of Microbiology, Guangzhou 510070, China*

[*] Correspondence to: *mycolab@263.net*

Abstract—*Gymnopus ramulicola*, a new species of *G.* subsect. *Vestipedes*, is described from China. It is characterized by a pale red to pinkish white pileus, adnate to subfree lamellae, a (sub)insititious stipe with white mycelium at an enlarged base, a simple pileipellis cutis with occasional weakly diverticulate elements, abundant clamp connections, and habitat on twigs or sticks of broadleaved trees. The new species is compared with similar species in its subsection, and its phylogenetic position is inferred by a maximum likelihood tree based on ITS sequences.

Key words—*Omphalotaceae*, phylogeny, taxonomy

Introduction

During several macrofungal field surveys in southern China, three interesting gymnopoid collections were obtained from Hainan and Jiangxi provinces. Morphological examination and internal transcribed spacer (ITS) sequence analysis indicated that the specimens represented *Gymnopus* (Pers.) Roussel (*Omphalotaceae*, *Agaricales*).

Although 329 *Gymnopus* names have been published, only 204 are currently accepted in the genus (http://www.indexfungorum.org/Names/Names.asp — accessed Oct 9. 2015). China is very rich in fungal diversity, but only 17 species of *Gymnopus* have been reported in the country (Li et al. 2006, Bau et al. 2007, Wu et al. 2009, Deng et al. 2011, Mešić et al. 2011, Zhang & Liu. 2011, Zhang et al. 2012, Li et al. 2012); there are probably many more taxa to be discovered.

Morphological examination of the gymnopoid collections supports placement in *Gymnopus* subsect. *Vestipedes*, which is characterized by small to medium-sized basidiomata, a membranaceous or thin-fleshed pileus, a non-grooved and rootless stipe, a sterile lamella edge with well-differentiated cheilocystidia, and a pileipellis usually with some weakly to distinctly coralloid or diverticulate terminal elements (Antonín & Noordeloos 1997). Most members of this subsection were formerly placed in *Collybia* sect. *Vestipedes* (Kühner 1980, Halling 1983, Jansen 1991), but they were transferred to *Gymnopus* subsect. *Vestipedes* after *Collybia* sensu lato was divided into *Collybia* sensu stricto, *Gymnopus*, and *Rhodocollybia* (Antonín & Noordeloos 1997). After comparison with other species in *G.* subsect. *Vestipedes*, our Chinese taxon was determined to represent a new species, described here as *G. ramulicola*.

Material & methods

Morphological studies

The description of the new species is based on specimens and field photos. Macroscopic features were recorded in the field. Colour codes in the macroscopic description follow Kornerup & Wanscher (1978). Microscopic features were observed from dried material after being sectioned and mounted in 5% potassium hydroxide (KOH) or 1% Congo Red under an Olympus BX51 light microscope (Tokyo). The notation (a–)b–c(–d) is used to present dimensions where the range b–c represents over 90% of the measured values, and both 'a' and 'd' are the extreme values; "n" refers to the number of measured basidiospores, "Q" refers to the length/width ratio of basidiospores, and Q_m refers to the mean ratio. Holotype and paratypes are deposited in the Fungal Herbarium, Guangdong Institute of Microbiology, Guangzhou, China (GDGM).

Molecular procedures and phylogenetic analyses

Genomic DNA was extracted from dried specimens with the Sangon Fungus Genomic DNA Extraction kit (Sangon Biotech Co., Shanghai) according to manufacturer's instructions. The primers ITS1 and ITS4 (White et al. 1990, Gardes & Bruns 1993) were used to amplify nuclear ribosomal internal transcribed spacer region, containing the ITS1, 5.8S and ITS2 regions. Dideoxy sequencing was performed by Beijing Genomic Institute (Guangzhou, China) using the ABI 3730xl DNA sequencer (Applied Biosystems, Foster City, CA, USA). ITS sequences from 22 species taken from GenBank were used to construct a maximum likelihood tree after these sequences were edited and aligned by MEGA 6.0. Relative robustness of individual branches was estimated by bootstrapping 1000 replications.

Results

Molecular results

The phylogenetic analysis contains 25 sequences, among which 22 were downloaded from GenBank. Sequences JN714927 (*Marasmius* type species

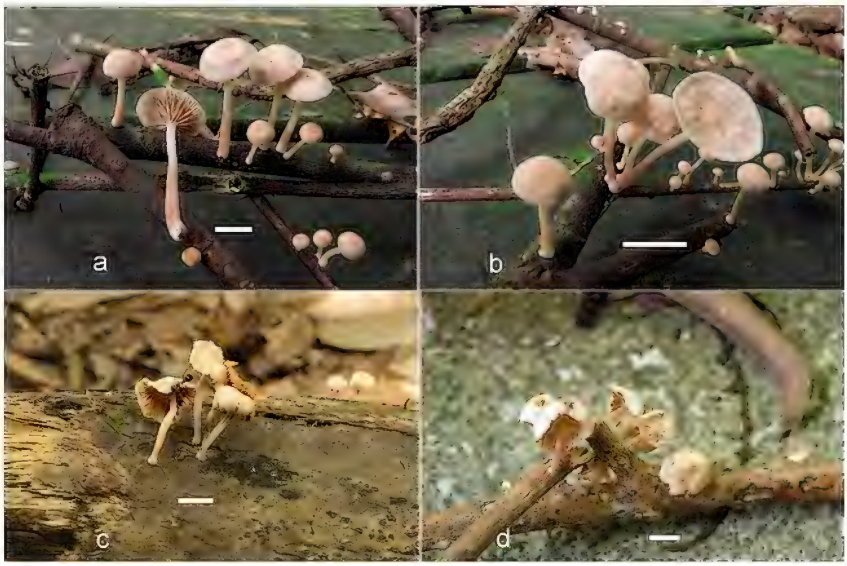


Fig. 1. *Gymnopus ramulicola* basidiomata.
a, b. holotype, GDGM 43884; c. GDGM 44256; d. GDGM 50060. Scale bars = 10 mm.

M. rotula (Scop.) Fr.) and JN021008 (*Collybia* type species *C. tuberosa* (Bull.) P. Kumm.) were selected as outgroup. Maximum likelihood analysis of ITS sequences representing *Gymnopus* sections *Gymnopus*, *Vestipedes*, *Laevipedes*, and *Androsacei* placed our three Chinese sequences in a single lineage and supported our new species as a member of *G.* sect. *Vestipedes*.

Taxonomy

Gymnopus ramulicola T.H. Li & S.F. Deng **sp. nov.** Figs 1, 2

MycoBank MB 815128

Differs from *Gymnopus melanopus* by its pale red to pinkish white pileus, shorter and white to greyish red or dull red stipe, smaller basidiospores, and smaller cheilocystidia; and from *G. confluens* by its smaller pileus, distant lamellae, shorter stipe, and its gregarious habit on fallen twigs.

Type: China, Hainan Province: Ledong County, Jianfengling National Forest Park, 18°43′36″N 108°53′56″E, alt. 787 m asl, 29 June 2013, leg. Wang CQ, Zhou SH (**Holotype**, GDGM 43884; GenBank KU057798).

Etymology: epithet *ramulicola* indicates that the new species is growing on fallen twigs.

Pileus 5–25 mm broad, hemispherical to convex when young, expanding to applanate with a slightly uplifted margin, pale red (7A3, 8A3, 9A3) to pastel red (7A4, 8A4) at disc and reddish or pinkish white (9A2, 10A2) at margin when

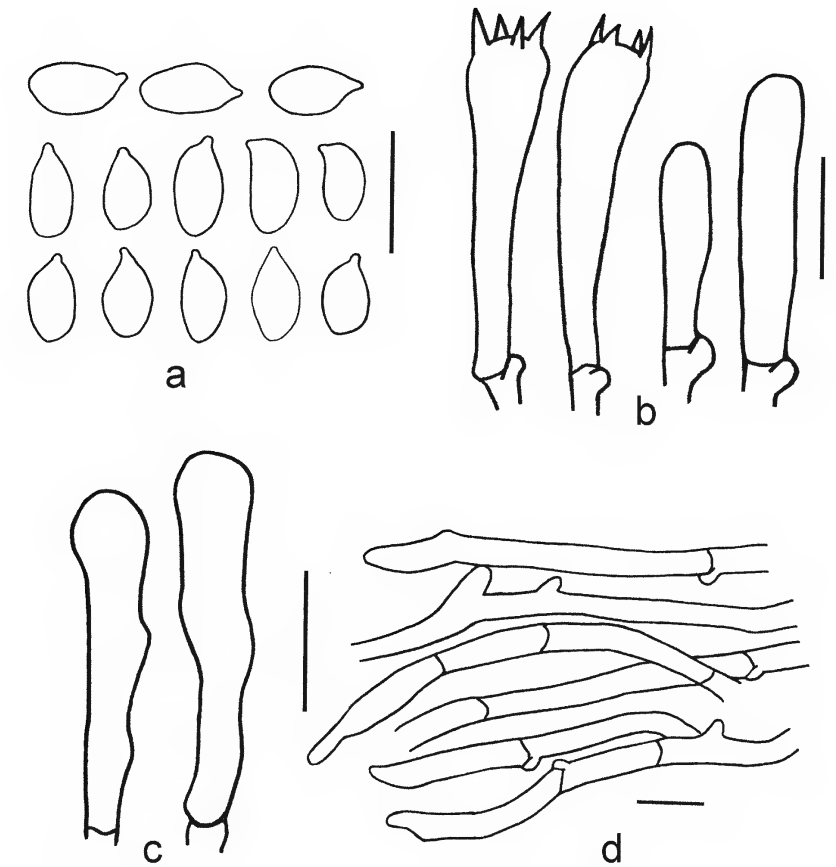


Fig. 2. *Gymnopus ramulicola*. (holotype, GDGM43884).
a. basidiospores; b. basidia and basidioles; c. cheilocystidia ; d. pileipellis. Scale bars = 10 μm.

young, sometimes greyish orange (6B3–4), greyish red (7B3–4) or dull red (8B3, 8C3), usually paler when mature, becoming orange white or pale orange (5A2–3, 6A2–3) to yellowish white or pale yellow (3A2–3, 4A2–3) when old, dry, with inconspicuous radial stripes or grooves and fine white tomentum. Lamellae adnate to sub-free, narrow, distant, with 9–12 complete lamellae and 1–4 lamellulae of different lengths between the two complete lamellae, concolourous with pileus to somewhat dull red or greyish red (8B4 to 9B5, 8C4–5). Stipe central, 12–23 × 2–3 mm, cylindrical, hollow, often slightly

inflated at the base, (sub)insititious, white at apex, becoming greyish red (7B3–4) or dull red (8B3, 8C3) downwards, dry, covered with fine white tomentum, and with white mycelium at base. Context thin, whitish to similar to pileus colour. Odour and taste not distinctive.

Basidiospores (n = 30) (6.3–)6.6–8.4(–8.8) × (3.2–)3.5–4.5 µm, Q = 1.6–2.4, Q_m = 1.94, ellipsoid to oblong, smooth, thin walled, hyaline. Basidia 23–27 (–30) × 3.8–5.5 µm, clavate to cylindrical, inflated at apex, thin-walled, with (2–)4 sterigmata, clamped. Basidioles 16–25 × 3.0–4.5 µm, cylindrical, clamped. Cheilocystidia 23–27(–30) × 3–6 µm, indistinct, irregularly clavate to cylindrical, inflated at apex, hyaline, thin-walled. Pleurocystidia absent. Pileipellis a cutis of radially arranged cylindrical hyphae which are 4–9 µm in diam., smooth, septate, thin-walled, and weakly to distinctly diverticulate. Clamp connections abundant and present in all tissues.

Habitat—gregarious on fallen twigs in tropical or subtropical broadleaf forests.

Additional specimens examined: **China**, **Hainan Province**: Changjiang County, Bawangling National Forest Park, 19°07′25″N 109°05′35″E, alt. 657 m asl, 6 June 2013, leg. Wang CQ, Zhou SH (GDGM 44256; GenBank KU321529); **Jiangxi Province**: Ganzhou City, Chongyiyang National Forest Park, 55°38′99″N 114°19′10″E, alt. 374 m asl, 2 August 2013, leg. Zhang M, Xu J, Zhou SH (GDGM 50060; GenBank KU321530).

Discussion

Among the species with ITS sequences in the phylogenetic tree (Fig. 3), *Gymnopus ramulicola* is closest to *G. melanopus* A.W. Wilson et al., which differs by its dark brown to greyish orange or beige pileus, its longer (21–55 mm) brown to black stipe, its larger basidiospores (7.2–10.4 × 3.2–5.6 µm), and its much larger cheilocystidia (32–56 × 9.5–16.5 µm; Wilson et al. 2004). The second closest taxon in the tree is *G. nonnullus* var. *attenuatus* (Corner) A.W. Wilson et al., which differs by its dark chocolate brown to grayish brown pileus, its larger basidiospores (7.2–9.6 × 3.2–4.8 µm), and its much larger cheilocystidia (37.5–60 × 5.5–7 µm; Wilson et al. 2004).

Morphologically, *G. confluens* (Pers.) Antonín et al., *G. huijsmanii* Antonin & Noordel., *G. inodorus* (Pat.) Antonín & Noordel., *G. moseri* Antonín & Noordel., and *G. putillus* (Fr.) Antonín et al. (all in *G.* subsect. *Vestipedes;* Antonín & Noordeloos 1997) somewhat resemble *G. ramulicola*. However, *G. confluens* has a bigger (10–65 mm), pale brown, yellow-brown or pale grey-brown pileus, more crowded lamellae, and a longer, distinctly non-insititious stipe (25–90 × 1.5–4 mm; Halling 1983, Antonín & Noordeloos 1997); *G. huijsmanii* has incarnate to violaceous brown stipe, larger basidiospores (6.5–11.5 × 3.5–5.5 µm; Antonín & Noordeloos 1997); *G. inodorus* has more

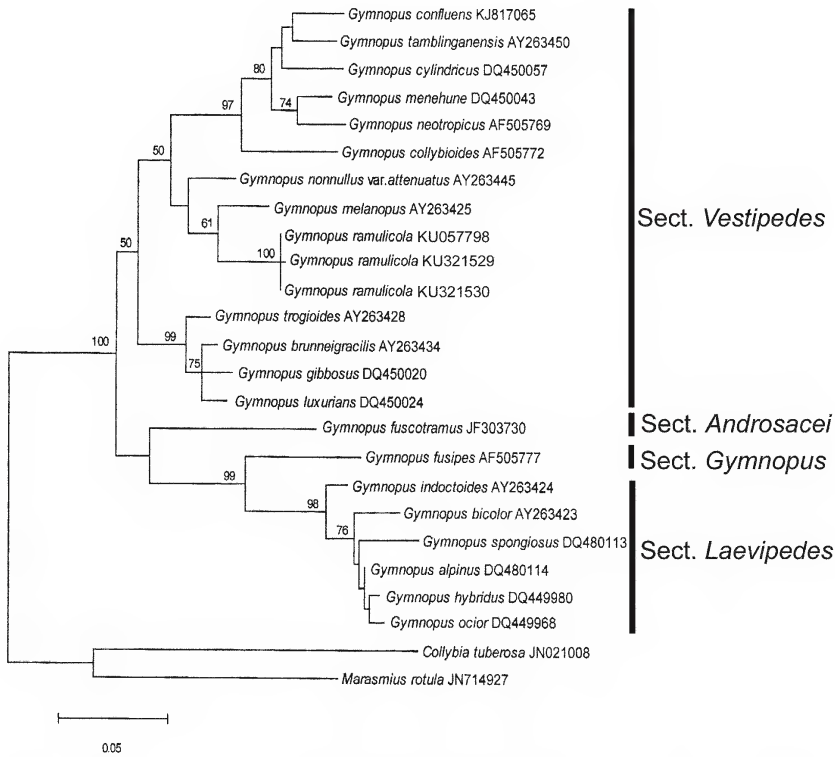


FIG. 3. Phylogenetic tree based on the ITS rDNA region (ITS1, 5.8S rDNA and ITS2), maximum likelihood tree after sequences being edited and aligned by MEGA 6.0. Relative robustness of individual branches was estimated by bootstrapping 1000 replications. Bootstrap values (>50%) are shown above individual nodes.

crowded lamellae and strongly inflated cheilocystidia that typically have finger-like apical excrescencies (Antonín & Noordeloos 1997); *G. moseri* has a brown to red-brown stipe and larger basidiospores (8.5–11.0 × 4.0–5.0 μm; Antonín & Noordeloos 1997); and *G putillus* has more crowded lamellae, a brown or greyish brown, white to greyish pruinose stipe, and no cheilocystidia (Antonín & Noordeloos 1997);

Among the other species in *Gymnopus* sect. *Vestipedes* with clamp connections, thin-fleshed pileus, and a non-grooved and non-insititious stipe, *G. allegreti* (De Seynes) A.W. Wilson et al. is distinguished by a light brown to pale yellowish brown pileus, a longer stipe with coarse rhizomorphs, and larger

cheilocystidia (33–46.5 × 6.5–10 µm; Wilson et al. 2004); *G. brunneigracilis* (Corner) A.W. Wilson et al. has a rusty reddish brown to light brown pileus and larger basidiospores (8–13.6 × 4.0–6.1 µm; Wilson et al. 2004); *G. collybioides* (Speg.) Desjardin et al. has smaller basidiospores (5.6–7.2 × 2.4–4.0 µm) and basidia (16–18 × 4–5 µm; Mata & Petersen 2003); *G. cylindricus* J.L. Mata has crowded lamellae and longer basidiospores (8.8–13.6 × 3.2–4.8 µm; Mata et al. 2004); *G. indoctus* (Corner) A.W. Wilson et al. has a brownish beige or creamy beige to white pileus, a longer, fibrillose stipe with rhizoids at the base, smaller basidia and somewhat larger cheilocystidia (26.5–35 × 9–12 µm; Wilson et al. 2004); *G. johnstonii* (Murrill) A.W. Wilson et al. has a dark brownish grey to brown pileus, more crowded lamellae, smaller basidia (12–17.5 × 5.5–10.5 µm), and cheilocystidia bifid or with a few lobes (Wilson et al. 2004); *G. luxurians* (Peck) Murrill has a larger, reddish brown to light brown pileus, more crowded lamellae, a stipe with rhizoids, and somewhat diverticulate cheilocystidia (Halling 1983); *G. menehune* Desjardin et al. has a reddish brown to dark brown or brown young pileus, close to crowded lamellulae, larger basidiospores (7.5–9.5 × 3.5–4.2 µm), and lobed and diverticulate cheilocystidia (16–42 × 3.8–10.0 µm; Desjardin et al. 1999); and *G. virescens* A.W. Wilson et al. has a dark reddish brown to light brown or light grey pileus, crowded lamellulae, a few coarse rhizomorphs at the base of stipe, larger basidiospores (7–10 × 3–6 µm), and a lamellar edge lacking cheilocystidia (Wilson et al. 2004).

Acknowledgments

Thanks are given to Shi-Hao Zhou, Ming Zhang and Jiang Xu for their help in collecting the specimens. We are grateful to Dr. Vladimír Antonín (Moravian Museum, Department of Botany, Brno, Czech Republic) and Dr. Armin Mešić (Ruđer Bošković Institute, Zagreb, Croatia) for their pre-submission reviews. This work was supported by the National Natural Science Foundation of China (Nos. 31260011, 31570020), the Ministry of Science and Technology of the People's Republic of China (Nos. 2014CB460613, 2013FY111200) and the Science and Technology Planning Project of Guangzhou (No. 201504291620324).

Literature cited

Antonín V, Noordeloos ME. 1997. A monograph of *Marasmius*, *Collybia* and related genera in Europe. Part 2: *Collybia*, *Gymnopus*, *Rhodocollybia*, *Crinipellis*, *Chaetocalathus*, and additions to *Marasmiellus*. Libri Botanici 17. 256 p.

Bau T, Bulakh YM, Zhuang JY, Li Y. 2007. Agarics and other macrobasidiomycetes from Ussuri River Valley. Mycosystema 26(3): 349–368.

Deng CY, Li TH, Song B. 2011. A revised checklist of *Marasmiellus* for China mainland. Czech Mycol. 63(2): 203–214.

Desjardin DE, Halling RE, Hemmes DE. 1999. *Agaricales* of the Hawaiian Islands. 5. The genera *Rhodocollybia* and *Gymnopus*. Mycologia 91(1): 166–176. http://dx.doi.org/10.2307/3761206

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. Molec. Ecol. 2: 113–118. http://dx.doi.org/10.1111/j.1365-294X.1993.tb00005.x

Halling RE. 1983. The genus *Collybia* (*Agaricales*) in the northeastern United States and adjacent Canada. Mycol. Mem. 8. 148 p.

Jansen AE. 1991. Het geslacht *Collybia*. Wetensch. Meded. Kon. Ned. Natuurhist. Ver. 205: 64 p.

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. London, Eyre Methuen.

Kühner R. 1980. Les hyménomycetes agaricoïdes (*Agaricales*, *Tricholomatales*, *Pluteales*, *Russulales*). Bull. Mens. Soc. Linn. Lyon 49(num. spéc.): 1027 p.

Li JZ, Chen SM, Dan XQ. 2006. Macrofungus resources of the Shunhuang Mountain Natural Protection Region. Life Sci. Res. 10(3): 276–281.

Li SJ, Zhu TH, Liu GH, Zhu HM. 2012. Diversity of macrofungal community in Bifeng Gorge: the core giant panda habitat in China. African J. Biotechnol. 11(8): 1970–1976. http://dx.doi.org/10.5897/AJB11.3232

Mata JL, Petersen RH. 2003. Type studies of neotropical *Collybia* species. Mycotaxon 86: 303–316.

Mata JL, Halling RE, Petersen RH. 2004. New species and mating system reports in *Gymnopus* (*Agaricales*) from Costa Rica. Fungal Diversity 16: 113–129.

Mešić A, Tkalčec Z, Deng CY, Li TH, Pleše B, Ćetković H. 2011. *Gymnopus fuscotramus* (*Agaricales*), a new species from southern China. Mycotaxon 117: 321–330. http://dx.doi.org/10.5248/117.321

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenies. 315–322, in: MA Innis et al. (eds). PCR protocols, a guide to methods and applications. Academic Press, San Diego. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

Wilson AW, Desjardin DE, Horak E. 2004. *Agaricales* of Indonesia. 5. The genus *Gymnopus* from Java and Bali. Sydowia 56(1): 137–210.

Wu XL, Li TH, Song B. 2009. The ecological distribution and resources of the macrofungi in Huaping Nature Reserve of Guangxi, China. Mycosystema 28(4): 528–534.

Zhang J, Liu PG. 2011. Wild economic macrofungi in Bijie District of Guizhou province, southwest China. Chin. J. Ecol. 30(6): 1177–1184.

Zhang Y, Zhou TS, Ou XK, Zhou DQ. 2012. New records and distribution of macrofungi in Laojun Mountain, Northwest Yunnan, China. Mycosystema 31(2): 196–212.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 671–678

http://dx.doi.org/10.5248/131.671

Hemithecium hainanense sp. nov. and a checklist and key to *Hemithecium* species from China

Ze-Feng Jia*, Mei-Fang Li & Xin Zhao

College of Life Sciences, Liaocheng University, Liaocheng, 252059, China

* Correspondence to: *zfjia2008@163.com*

Abstract—*Hemithecium hainanense* from Hainan Island, China, is described as new to science. The lichen is characterized by erumpent lirellae with a lateral to complete thalline margin, large transparent transversely septate ascospores, and the presence of norstictic acid. *Hemithecium chlorocarpum* is reported as a new record from China. A checklist and key to *Hemithecium* species from China are presented.

Key word—*Ascomycota, Graphidaceae, Ostropales, Ostropomycetidae,* taxonomy

Introduction

The lichenized fungal genus *Hemithecium* Trevis. (*Graphidaceae*, *Ostopales*) has been recently revised (Staiger 2002; Staiger et al. 2006; Lücking et al. 2008; Rivas Plata et al. 2012, 2013; Lumbsch et al. 2014; Miadlikowska et al. 2014). The genus is characterized by its crustose thalli, lirelliform apothecia, well-developed convergent labia, concealed discs, non-carbonized exciples, simple paraphyses, and hyaline transversely septate or muriform ascospores.

Hemithecium contains about 50 species worldwide (Staiger 2002, Upreti et al. 2011, Sharma et al. 2012). Miao et al. (2007) reported three species of *Hemithecium* (*H. chapadanum*, *H. chlorocarpoides*, and *H. chrysenteron*) as new records from China, which Lücking et al. (2008) since placed in the invalid genus "*Pallidogramme*". During the compilation of the Flora Lichenum Sinicorum, five *Hemithecium* species were recognized in China (Jia et al. 2011, Jia & Wei 2016). Here, we describe a new species, *Hemithecium hainanense*, and add a new Chinese record, *H. chlorocarpum*.

Materials & methods

The specimens are deposited in the Herbarium Mycologicum Academiae Sinicae – Lichenes, Beijing, China (HMAS-L) and the Lichen Herbarium of the College of Life Sciences, Liaocheng University, Liaocheng, China (LCU-L). Morphological and anatomical features were examined using an Olympus SZX12 dissecting microscope and Olympus BX51 & Nikon Eclipse-55i light microscopes. Measurements and illustrations were taken from the hand cut cross-sections of fruit bodies in tap water. Amyloidity of the ascospores was tested using Lugol's solution. The thallus surface and thin thallus sections were spot tested with K (KOH, 20%), C (saturated solution of NaOCl), and P (ethanol solution of p-phenylenediamine, 5%) reagents. The lichen substances were detected and identified by thin-layer chromatography (TLC; Culberson & Kristinsson 1970, Culberson 1972, White & James 1985).

Taxonomy

Hemithecium hainanense Z.F. Jia, **sp. nov.** Pl. 1

Fungal Name FN570071

Differs from *Hemithecium implicatum* by its longer ascospores and presence of norstictic acid.

Type: China. Hainan Province, Changjiang County, Mt. Bawangling, Yajia, 19°14′N 109°26′E, alt. 800 m, on bark, 10/V/2008, J. Li HN081472 (**Holotype**, HMAS-L 127460).

Etymology: The specific epithet *hainanense* is derived from the type locality, *Hainan*, and *-ense*, Latin, place of origin.

Thallus corticolous, crustose, pale to grayish white, thin, slightly smooth, tightly attached to the substratum, lacking isidia and soredia.

Apothecia lirelliform, numerous, elongate, simple, rarely branched, erumpent, not striate, 1–4 mm long, 0.1–0.2 mm wide, covered by lateral to complete thalline margin; disc concealed, with slit-like appearance; proper exciple conspicuous, convergent, uncarbonized, yellowish to brown; hymenium clear, 110–180 μm high, I–, with brownish epihymenium; hypothecium brownish, 5–15 μm high. Paraphyses simple, 1–2 μm wide. Asci clavate, 90–130 × 15–20 μm, 6–8-spored. Ascospores hyaline, surrounded by a thin halo, narrowly ellipsoidal, transversely septate, with 17–20 locules, 50–100 μm long and 6.5–10 μm wide, I+ violet.

Chemistry: K+ red, C–, P+ yellow; norstictic acid present (TLC).

Substrate: on bark.

Additional specimens examined: **China. Hainan Province,** Changjiang County, Mt. Bawangling, alt. 800 m, 10/V/2008, J. Li HN081467 (HMAS-L 127462), HN081470 (HMAS-L 127461); Qiongzhong County, Mt. Limushan, alt. 650 m, 25/IX/2009, B. Gao HN080910 (HMAS-L 127464), J. Li HN081236 (HMAS-L 127463); Ledong County, Mt. Jianfengling, alt. 900 m, M. Liu HN09414 (HMAS-L 115510).

Ecology & distribution: *Hemithecium hainanse* is known from altitudes of 650–900 m in a tropical rainforest on Hainan Island in southern China where

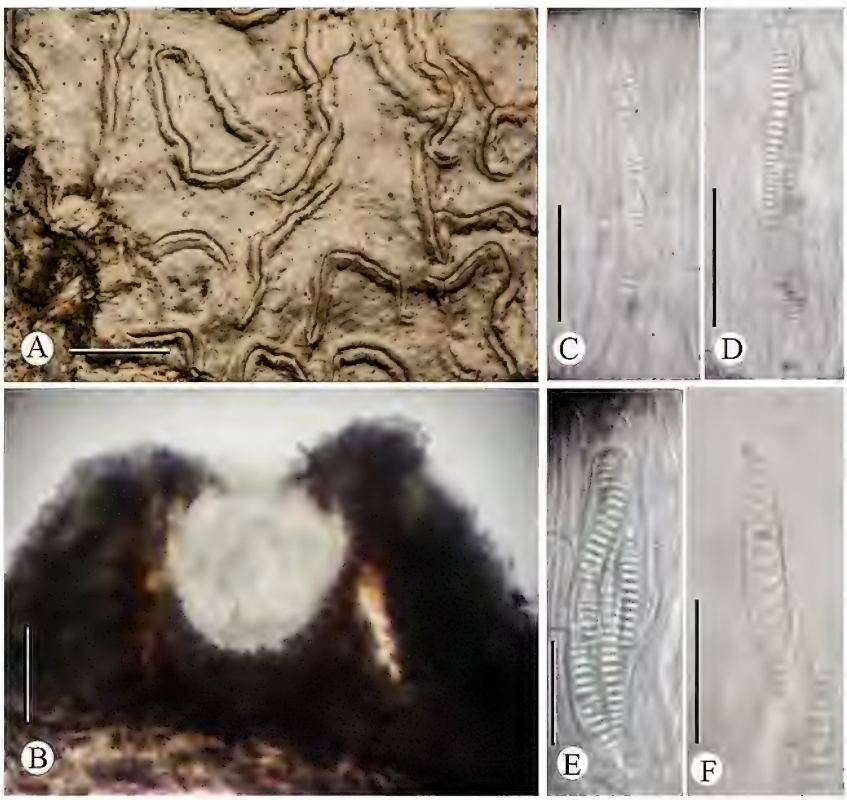


Plate 1. ***Hemithecium hainanense*** (holotype, HMAS-L 127460). A. Thallus on bark; B. Cross section of apothecium; C–E. Asci containing ascospores (showing the process of ascospore development and maturation); F. Mature ascospores. Scale bars: A = 1 mm; B = 100 μm; C–F = 50 μm.

it grows on smooth bark in moist and humid places. Associated lichen species include *Diorygma hieroglyphicum* (Pers.) Staiger & Kalb, *Graphis hossei* Vain., *G. japonica* (Müll. Arg.) A.W. Archer & Lücking, "*Pallidogramme chrysenteron*" (Mont.) Staiger et al., and other members of the *Graphidaceae*.

Remarks: *Hemithecium hainanense* is characterized by simple and sparsely branched erumpent lirellae with a lateral to complete thalline margin, a concealed disc, an uncarbonized exciple, a clear hymenium, transversely septate ascospores of 50–100 × 6.5–10 μm, and the presence of norstictic acid. The new species resembles *Hemithecium implicatum* but is distinguished from the latter by the larger transversely septate ascospores and the presence of norstictic acid.

Hemithecium balbisii (Fée) Trevis., Spighe e Paglie: 13 (1853).

Thallus corticolous, greenish-gray, upper surface waxy. Apothecia lirelliform, 2–8 mm long, 0.3–0.4 mm wide, sometimes branched, covered partly by the cream-colored, indistinctly crenate thalline margin. Discs concealed. Proper exciple convergent, pale to brown. Hymenium clear, 80–90 μm high. Ascospores 8/ascus, hyaline, elongate, muriform, 10–12 × 2–4-locular, 28–50 μm long and 10–15μm wide, I+ violet, lacking a surrounding halo.

Chemistry: K–, C–, P–; no substances present (TLC).

Substrate: on bark.

Specimens examined: **CHINA. Fujian Province**, Wuyishan City, Mt. Wuyishan, alt. 540 m, 27/V/2007, J. Li FJ502 (LCU-L). **Hainan Province**, Baoting County, Mt. Qixianling, alt. 200 m, 23/VII/2009, J. Li HN240-1 (HMAS-L 125725); Ledong County, Mt. Nanlimu, alt. 180 m, 22/VII/2009, M. Liu HN09357 (HMAS-L 115556). **Yunnan Province**, Honghe City, Mt. Daweishan, alt. 900 m, 23/IX/2011, Z.F. Jia 11-455 (LCU-L); 1250 m, 23/IX/2011, Z.F. Jia 11-508-3 (LCU-L).

Remarks: The species is similar in appearance to "*Pallidogramme chlorocarpoides,*" which differs by its larger, brown ascospores and its production of stictic acid. *Hemithecium balbisii* was previously reported from an unstated locality in China as *Graphis balbisii* Fée (Krempelhuber 1868; Wei 1991). A pantropical species, *H. balbisii* also occurs in South America (Staiger 2002).

Hemithecium canlaonense (Vain.) A.W. Archer, Syst. Biodiv. 5: 17 (2007).

Thallus corticolous, gray to greenish-gray, upper surface waxy. Apothecia lirelliform, 1–3 mm long, 0.2–0.3 mm wide, sometimes branched, covered partly by the indistinctly crenate thalline margin. Discs concealed. Proper exciple convergent, pale to brown. Hymenium clear, 80–110 μm high. Ascospores 8/ascus, hyaline, ellipsoidal, transversely septate, 4-locular, 15–25 μm long and 8–14 μm wide, I–, lacking a surrounding halo.

Chemistry: K–, C–, P–; no substances present (TLC).

Substrate: on bark.

Specimens examined: **CHINA. Guizhou Province**, Tongren City, Mt. Fanjingshan, alt. 133 m, on bark, 16/IX/1963, J.C. Wei 0762 (HMAS-L 047793), 0763 (HMAS-L 047790).

Remarks: The species is similar to *H. oshioi*, but differs by its smaller ascospores and the absence of stictic acid. *Hemithecium canlaonense* was previously reported in China as *Fissurina canlaonensis* (Vain.) Staiger (Meng et al. 2011). This pantropical species also occurs in Indonesia and the Philippines (Archer 2007) and in India (Patwardhan & Kulkarni 1976; Sharma et al. 2012) where it was recorded as *Fissurina canlaonensis*.

Hemithecium chlorocarpum (Fée) Trevis., Spighe e Paglie : 12 (1853).

Thallus corticolous, pale gray to greenish-gray, surface smooth. Apothecia lirelliform, 1–4 mm long, 0.2–0.4 mm wide, sometimes branched, covered partly by the distinctly crenate, thalline margin. Discs concealed. Proper exciple convergent, pale to brown. Hymenium clear, 150–180 µm high. Ascospores 1/ascus, hyaline, ellipsoidal, muriform, 20–30 × 5–8-locular, 85–125 µm long and 18–27.5 µm wide, I+ violet, lacking a surrounding halo.

Chemistry: K–, C–, P–; no substances present (TLC).

Substrate: on bark.

Specimen examined: **CHINA. Hainan Province**, Wuzhishan City, Mt. Wuzhishan, alt. 750 m, on bark, 28/VI/2001, J.B. Chen 20657 (HMAS-L 076854)

Remarks: The species resembles *Hemithecium balbisii*, but differs by its larger ascospores and asci containing one ascospore. *Hemithecium chlorocarpum* is here reported as new to China. As a pantropical element, it also occurs in South America (Staiger 2002).

Hemithecium duomurisporum Z.F. Jia, Mycosystema 30: 871 (2011).

Thallus corticolous, grayish to olive-green, smooth. Apothecia lirelliform, 2–8 mm long and 0.3–0.5 mm wide, rarely branched, covered partly by the slightly crenate thalline margin. Discs concealed. Proper exciple convergent, yellow-brown. Hymenium clear, 150–180 µm high. Ascospores 1/ascus, hyaline, lacking a surrounding halo, elongate, muriform, with 20–22 × 3–9-locular with the traverse septa doubled, 100–140 µm long and 20–29 µm wide, I+ violet.

Chemistry: K+ yellow, C–, P+ orange; stictic acid present (TLC).

Substrate: on bark.

Specimens examined: **China. Hainan Province**, Wuzhishan City, Mt. Wuzhishan, alt. 640 m, 20/VII/2009, M. Liu HN09318 (HMAS-L 115536); alt. 680 m, 28/IX/2008, Z.F. Jia HN0080706 (HMAS-L 127486). Qiongzhong County, Mt. Limushan, 750 m, 25/XI/2008, J, Li HN081229 (HMAS-L 126329).

Remarks: This species is characterized by the large muriform ascospores and presence of stictic acid. It is similar to *H. chlorocarpum*, which differs by its smaller ascospores and its lack of lichen substances (see the description above). *Hemithecium duomurisporum* was previously recorded from Hainan, China (Jia et al. 2011).

Hemithecium implicatum (Fée) Staiger, Biblioth. Lichenol. 85: 287 (2002).

Thallus corticolous, greenish, slightly smooth. Apothecia lirelliform, 1–5 mm long and 0.1–0.2 mm wide, often branched, covered partly by the

indistinctly crenate thalline margin. Discs concealed, with slit-like appearance. Proper exciple convergent, yellowish to brown. Hymenium clear, 100–150 µm high. Ascospores 2–8/ascus, hyaline, lacking a surrounding halo, elongate, transversely septate with 15–23 locules, 35–80 µm long and 5.5–9 µm wide, I+ violet.

Chemistry: K–, C–, P–; no substances present (TLC).

Substrate: on bark.

Specimens examined: **CHINA. Hainan Province**, Ledong County, Mt. Jianfengling, 900–950 m, 26–28/VII/2009, J. Li HN09127 (HMAS-L 115454), HN09128 (HMAS-L 115437), HN09218 (HMAS-L 115502); Changjiang County, Mt. Bawangling, 880 m, 25/X/2008, J. Li HN081456 (HMAS-L 117055), HN081477 (HMAS-L 126330), HN081478 (HMAS-L 126298); Qiongzhong County, Mt. Limushan, 650 m, 25/IX/2008, J. Li HN081237 (HMAS-L 117096), HN081465 (HMAS-L 117097); Wuzhishan City, Mt. Wuzhishan, 680 m, 20/VII/2009, J. Li HN09064 (HMAS-L 115475), HN204 (HMAS-L 117067).

Remarks: This species is similar in appearance to *H. oshioi*, which is distinguished by its shorter ascospores and its production of lichen substances (see the description below). *Hemithecium implicatum* also occurs in Mexico (Wirth & Hale 1963, as *Graphis implicata*) and Brazil (Staiger 2002).

Hemithecium oshioi (M. Nakan.) M. Nakan. & Kashiw., Bull. Natl. Sci. Mus. Tokyo, B 29(2): 88 (2003).

Thallus corticolous, grayish, rough. Apothecia lirelliform, 0.5–3 mm long and 0.2–0.4 mm wide, rarely branched, covered partly by the indistinctly crenate thalline margin. Discs concealed. Proper exciple convergent, yellowish to brown. Hymenium clear, 90–120 µm high. Ascospores 2–6/ascus, hyaline, lacking a surrounding halo, elongate, with 5–9 transverse septa, 25–40 µm long and 5.5–8 µm wide, I+ violet.

Chemistry: K+ red, C–, P+ yellow; norstictic acid present (TLC).

Substrate: on bark.

Specimen examined: **CHINA. Fujian Province**, Jianou City, Fangdao Town, Wanmulin, 310 m, 3/VI/2007, Q.F. Meng FJ925 (LCU-L). **Hainan Province**, Wuzhishan City, Mt. Wuzhishan, 700 m, 21/VII/2009, J. Li HN09092 (HMAS-L 115471); 670 m, 28/IX/2008, T. Zhang HN080346 (HMAS-L 125726). Ledong County, Mt. Jianfengling, 850 m, 29/VII/2009, Z.F. Jia HNJ63 (HMAS-L 128787), HNJ64 (HMAS-L 128786).

Remarks: This species is similar to *H. laubertianum*, which differs by its thick-walled spores and its lack of lichen substances (Staiger 2002). *Hemithecium oshioi* was reported from Zhejiang, China (as *Graphis oshioi* M. Nakan.: Wu & Qian 1989, Wei 1991) and Hainan, China (Jia et al. 2011, Wei et al. 2013). It is also recorded from Japan (Nakanishi 1966, as *Graphis oshioi*).

Key to species of *Hemithecium* from China

1. Ascospores with transverse septa 2
1. Ascospores muriform 5
2. Ascospores 4-locular, 15–25 × 8–14 µm ..... ***H. canlaonense***
2. Ascospores >4-locular, >25 µm long 3
3. No substances present; ascospores 15–23-locular, 35–80 × 5.5–9 µm ***H. implicatum***
3. Norstictic acid present 4
4. Ascospores 17–20-locular, 50–100 × 6.5–10 µm ..... ***H. hainanense***
4. Ascospores 6–10-locular, 25–40 × 5.5–8 µm ..... ***H. oshioi***
5. Stictic acid present; ascospores 100–140 × 20–29 µm ..... ***H. duomurisporum***
5. No substances present 6
6. Ascospores 28–50 × 10–15 µm ..... ***H. balbisii***
6. Ascospores 85–125 × 18–27.5 µm ..... ***H. chlorocarpum***

Acknowledgements

This study was supported by the National Natural Science Foundation of China (31270066, 31093440, 31493010 & 31493011) and Shandong Excellent Youth Scientist Foundation Project (BS2011SW028). The authors are grateful to Dr. Alan W. Archer and Dr. Hua-Jie Liu for reading and improving the manuscript and for acting as presubmission reviewers.

Literature cited

Archer AW. 2007. Key and checklist for the lichen family *Graphidaceae* (lichenised *Ascomycota*) in the Solomon Islands. Systematics and Biodiversity 5: 9–22. http://dx.doi.org/10.1017/S1477200006002040

Culberson CF. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. Journal of Chromatography 72: 113–125. http://dx.doi.org/10.1016/0021-9673(72)80013-X

Culberson CF, Kristinsson H. 1970. A standardized method for the identification of lichen products. Journal of Chromatography 46: 85–93. http://dx.doi.org/10.1016/S0021-9673(00)83967-9

Jia ZF, Wei JC. 2016. Flora lichenum sinicorum – Vol. 13 – *Ostropales* (I). Science Press, Beijing. 210 p.

Jia ZF, Miao XL, Wei JC. 2011. A preliminary study of *Hemithecium* and *Pallidogramme* (*Graphidaceae*, *Ostropales*, *Ascomycota*) from China. Mycosystema 30(6): 870–876.

Krempelhuber A. 1868. Exotische Flechten aus dem Herbar des K.K. botanischen Hofkabinetes in Wien. Verhandlungen der Kaiserlich Königlichen Zoologisch-Botanischen Gesellschaft in Wien 18: 303–330.

Lücking R, Chaves JL, Sipman HJM, Umaña L, Aptroot A. 2008. A first assessment of the Ticolichen biodiversity inventory in Costa Rica: the genus *Graphis*, with notes on the genus *Hemithecium* (*Ascomycota*: *Ostropales*: *Graphidaceae*). Fieldiana Botany 46: 1–126. http://dx.doi.org/10.3158/0015-0746(2008)46[1:afaott]2.0.co;2

Lumbsch HT, Parnmen S, Kraichak E, Papong KB, Lücking R. 2014. High frequency of character transformations is phylogenetically structured within the lichenized fungal family *Graphidaceae* (*Ascomycota*: *Ostropales*). Systematics and Biodiversity 12(3): 271–291. http://dx.doi.org/10.1080/14772000.2014.905506

Meng QF, Fu SB, Wei JC. 2011. Taxonomical study on the lichen genus *Fissurina* in China. 157–168, in: HJ Liu et al. (eds). The present status and potentialities of the lichenology in China. Science Press, Bejing.

Miadlikowska J, Kauff F, Högnabba F, Oliver JC, Molnár K, Fraker E, Gaya E, Hafellner J, Hofstetter V, Gueidan C, Otálora MAG, Hodkinson B, Kukwa M, Lücking R, Björk C, Sipman HJM, Burgaz AR, Thell A, Passo A, Myllys L, Goward T, Fernández-Brime S, Hestmark G, Lendemer J, Lumbsch HT, Schmull M, Schoch CL, Sérusiaux E, Maddison DR, Arnold AE, Lutzoni F, Stenroos S. 2014. A multigene phylogenetic synthesis for the class *Lecanoromycetes* (*Ascomycota*): 1307 fungi representing 1139 infrageneric taxa, 317 genera and 66 families. Molecular Phylogenetics and Evolution 79: 132–168. http://dx.doi.org/10.1016/j.ympev.2014.04.003

Miao XL, Jia ZF, Meng QF, Wei JC. 2007. Some species of *Graphidaceae* (*Ostropales*, *Ascomycota*) rare and new to China. Mycosystema 26(4): 493–506.

Nakanishi M. 1966. Taxonomical studies on the family *Graphidaceae* of Japan. Journal of the Hiroshima University 11: 51–126.

Patwardhan PG, Kulkarni CR. 1976. Some additions to the lichen flora of India IV: *Graphis* and *Graphina* (family *Graphidaceae*). Biovigyanam 2: 123–132.

Rivas Plata E, Lücking R, Lumbsch HT. 2012. A new classification for the family *Graphidaceae* (*Ascomycota*: *Lecanoromycetes*: *Ostropales*). Fungal Diversity 52: 107–121. http://dx.doi.org/10.1007/s13225-011-0135-8

Rivas Plata E, Parnmen S, Staiger B, Mangold A, Frisch A, Weerakoon G, Hernández JE, Cáceres MES, Kalb K, Sipman HJM, Common RS, Nelsen MP, Lücking R, Lumbsch HT. 2013. A molecular phylogeny of *Graphidaceae* (*Ascomycota*, *Lecanoromycetes*, *Ostropales*) including 428 species. Mycokeys 6: 55–94. http://dx.doi.org/10.3897/mycokeys.6.3482

Sharma BO, Khadilkar P, Makhija U. 2012. New species and new combinations in the lichen genera *Fissurina* and *Hemithecium* from India. Lichenologist 44(3): 339–362. http://dx.doi.org/10.1017/S0024282911000752

Staiger B. 2002. Die Flechtenfamilie *Graphidaceae*: Studien in Richtung einer natürlicheren Gliederung. Bibliotheca Lichenologica 85. 526 p.

Staiger B, Kalb K, Grube M. 2006. Phylogeny and phenotypic variation in the lichen family *Graphidaceae* (*Ostropomycetidae*, *Ascomycota*). Mycological Research 110: 765–772. http://dx.doi.org/10.1016/j.mycres.2006.05.003

Upreti DK, Dubey U, Nayaka S. 2011. A new isidiate species of *Hemithecium* Trevis. (*Ascomycota*, *Graphidaceae*) from India. Lichenologist 43(5): 483–485. http://dx.doi.org/10.1017/S0024282911000430

Wei JC. 1991. An enumeration of lichens in China. International Academic Publishers, Beijing. 278 p.

Wei JC, Jia ZF, Wu XL. 2013. An investigation of lichen diversity from Hainan Island of China and prospect of the R & D of their resources—dedicated to the famous mycologist Prof. Wang Yun-chang. Journal of Fungal Research 11(4): 224–238.

White FJ, James PW. 1985. A new guide to microchemical techniques for the identification of lichen substances. British Lichen Society Bulletin 57(Suppl.): 1–41.

Wirth M, Hale ME. 1963. The lichen family *Graphidaceae* in Mexico. Contributions from the United States National Herbarium 36: 63–119.

Wu JN, Qiang ZG. 1989. Lichens. 158–266, in: BS Xu (ed.). Cryptogamic flora of the Yangtze Delta and adjacent regions. Shanghai Scientific & Technical Publisher, Shanghai.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 679–685

http://dx.doi.org/10.5248/131.679

First records of *Faurelina* in the Neotropics

Roger Fagner Ribeiro Melo [1*], Andrew N. Miller [2] & Leonor Costa Maia [1]

[1] *Universidade Federal de Pernambuco, Departamento de Micologia, Av. da Engenharia, s/n, 50740-600, Recife, Brazil*

[2] *University of Illinois at Urbana-Champaign, Illinois Natural History Survey, 1816 S. Oak St., Champaign, IL 61820, USA*

[*] Correspondence to: *rogerfrmelo@gmail.com*

Abstract—Two species of *Faurelina*, *F. fimigena* and *F. hispanica*, are recorded fruiting on herbivore dung collected in the Caatinga biome of the semi-arid region of Brazil. These represent the first records of this genus in the Neotropics. Descriptions, a photographic plate and a comparative table are provided, along with an identification key to the four species of *Faurelina*.

Key words—coprophilous fungi, *Didymellaceae*, non-ostiolate ascomycetes, *Pleosporales*

Introduction

Named after the French mycologist Louis Faurel (1907–73), *Faurelina* Locq.-Lin. was first described by Locquin-Linard (1975) as a new genus of cleistothecial ascomycetes. The genus has since had a problematic taxonomical history. At first *Faurelina* was tentatively placed in *Chadefaudiellaceae*, but this position was doubtful. *Chadefaudiellaceae* was validated by Benny & Kimbrough (1980), based on the suggestion by Faurel & Schotter, to include species with non-ostiolate immersed ascomata with a pseudoparenchymatous peridium and aerial thick-walled 'capillitium', enclosing catenulate, evanescent asci with non-dextrinoid ascospores devoid of germ pores (Cannon & Kirk 2007).

After examining the type species *Faurelina fimigena* [as *F. fimigenes*], Parguey-Leduc & Locquin-Linard (1976) stated that it belonged to the

ascolocular ascomycetes and concluded that it should be placed in the class formerly known as *Loculoascomycetes*. Two years later, von Arx (1978) transferred *Faurelina* to *Microascaceae* (*Microascales*), based mainly on the presence of dextrinoid ascospores without germ pores. Placement of *Faurelina* in *Microascales* was due in part to the work of Tang et al. (2007), who sequenced the nucLSU, nucSSU, and RPB2 gene regions from a single strain labelled as *Faurelina indica* (CBS 126.78), giving results identical to those of *Ceratocystis fimbriata*, the type species of *Ceratocystis* (*Microscales*). Réblová et al. (2011) reevaluated *Chadefaudiellaceae* based on the suggested affinity of *Faurelina indica* Arx et al. with *Microascales*; they believed that the material studied by Tang et al. (2007) was a different fungus and that the LSU sequence analysis suggested a relationship with *Didymellaceae* (*Pleosporales*, *Dothideomycetes*), thus corroborating the original hypothesis proposed by Parguey-Leduc & Locquin-Linard (1976), that *Faurelina* was related to fungi with an ascolocular development.

In Brazil, recent efforts to compile data on fungal diversity, distribution, and biogeography of fungi, include the discovery and delimitation of taxa in each biome and their substrate/climate relationship (Braga-Neto et al. 2013). This work contributes to these efforts in the semi-arid regions of South America by recording the discovery of an unreported genus in the Neotropics, represented by two species fruiting on herbivore dung in the Brazilian Caatinga biome.

Material & methods

Dung samples were collected from farms close to the Instituto Agronômico de Pernambuco (IPA) in Serra Talhada (7°54′59″S 38°17′00″W), in the semi-arid region of Pernambuco, Brazil. Fresh samples of goat, cattle, and horse dung were collected in clean plastic bags, taken to the laboratory, gently air dried when necessary, and incubated in moist chambers at room temperature (28 ± 2 °C) for at least 60 days under alternating natural light and dark periods. The specimen habit was observed directly from substrata under a Leica EZ4 stereomicroscope, and cleistothecia in different stages of maturation were mounted in tap water for measurements, description and identification under an Olympus BX51 compound microscope. High quality images were captured with a Qimaging QColor 3 digital camera mounted on an Olympus BX51 compound microscope using differential interference or phase contrast microscopy. Specimens were identified based on descriptions provided by Locquin-Linard (1975), Valldosera et al. (1987), and von Arx et al. (1988). Due to lack of material, no attempt was made to culture these specimens. Permanent slides were prepared with polyvinyl-lacto-glycerol (PVLG) and deposited at Herbarium Padre Camille Torrend, Departamento de Micologia, Universidade Federal de Pernambuco, Recife, Brazil (URM). Additional information regarding accessioned records, as well as photographic data can be accessed at the "INCT – Herbário Virtual da Flora e dos Fungos" database website (http://inct.florabrasil.net/).

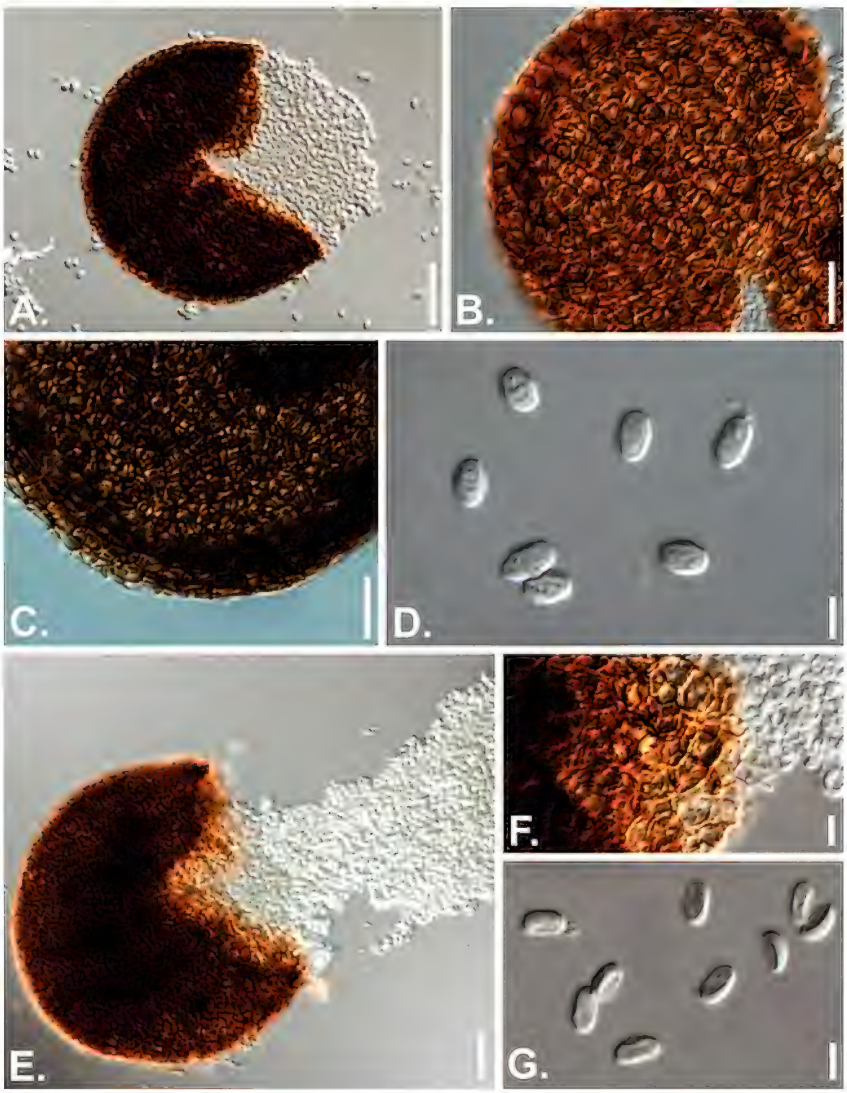


Figure 1. ***Faurelina fimigena*** (URM86671): A. cleistothecium in mountant, releasing mature ascospores; B, C. ascomatal wall; D. mature ascospores. ***Faurelina hispanica*** (URM86672): E. cleistothecium in mountant, releasing mature ascospores; F. ascomatal wall; G. mature ascospores. Scale bars: A = 50 µm; B, C = 25 µm; D = 7.5 µm; E = 30 µm; F, G = 5 µm.

Taxonomy

Faurelina fimigena Locq.-Lin., Rev. Mycol. (Paris) 39: 127 (1975) FIG. 1A–D

CLEISTOTHECIA immersed to superficial, solitary, globose to subglobose, dark red, 190–240 µm diam., with a roughened wall, glabrous. ASCOMATAL WALL composed of inflated, globose to slightly angular stromatic cells (textura globulosa), thick-walled, rusty red to copper in color, 5–7.5 µm diam. INTERASCAL ELEMENTS not observed in the examined material. ASCI 8-spored, globose to subglobose, often slightly clavate, 10–15.5 × 8–12.5 µm, occasionally with a short stipe, forming short chains during ascospore maturation, evanescent, irregularly biseriate. ASCOSPORES variable in morphology, ellipsoid, rhomboid or angulated, with abrupt ends, hyaline to slightly pale brown when mature, one-celled, with longitudinal striae and furrows, thick-walled, 7.5–10 × 4.5–5.5 µm.

MATERIAL EXAMINED — **BRAZIL. PERNAMBUCO**, Instituto Agronômico de Pernambuco (IPA), Serra Talhada, on cattle dung, 28.VIII.2012, R.F.R Melo (URM86671).

HABITAT: Recorded on cattle and goat dung.

DISTRIBUTION: Asia (India, Japan), Europe (France), South America (Brazil). This is the first record from South America.

NOTES: *Faurelina fimigena* is the type species of the genus, described by Locquin-Linard from material obtained in Paris. Although the records are scarce making it difficult to delimit the species, it differs from the other *Faurelina* species by ascospore shape and size. The ascospores in the Brazilian material are longer than those cited in the original description but are similar to the specimens analyzed by von Arx et al. (1988) obtained from subcultures of the type material. *Faurelina fimigena* resembles *F. elongata* (Udagawa & Furuya) Furuya [≡ *Leuconeurospora elongata* Udagawa & Furuya], and there has been some confusion in the delimitation of these species. However, *F. fimigena* differs from *F. elongata* in ascospore length.

Faurelina hispanica Valldos. & Guarro, Mycotaxon 30: 5 (1987) FIG. 1E–G

CLEISTOTHECIA immersed to superficial, solitary, globose, dark red, 195–210 µm diam., glabrous. ASCOMATAL WALL composed of inflated, globose to slightly angled stromatic cells (textura globulosa), thick-walled, rusty red to copper in color, 5–10 µm diam. INTERASCAL ELEMENTS not observed in the examined material. ASCI 8-spored, clavate to cylindrical-clavate, 11–12.5 × 5–9.5 µm, occasionally with a short stipe, forming short chains during ascospore maturation, evanescent, irregularly biseriate. ASCOSPORES ellipsoidal to oblong, with rounded ends, hyaline to slightly pale brown when

Table 1. Synopsis of diagnostic characters in *Faurelina*

Species	Cleistothecia	Peridium	Ascospores	Conidia
F. elongata	Vertically elongated, 300–360 µm diam.	Cephalothecoid; cells thick-walled, angular	Fusiform to ellipsoidal, 5–7 × 3.5–4.5 µm	Absent or not observed
F. fimigena	Globose to subglobose, wall roughened; 190–240 µm diam.	Non-cephalothecoid; cells globose inflated, thick-walled, rusty red to copper in color, 5–7.5 µm diam.	Ellipsoidal, rhomboidal or angular, with abrupt ends, longitudinally striate and furrowed; thick-walled, 7.5–10 × 4.5–5.5 µm.	Absent or not observed
F. hispanica	Globose, 195–210 µm diam.	Non-cephalothecoid; cells globose inflated, thick-walled, rusty red to copper in color, 5–10 µm diam.	Ellipsoidal to oblong, with rounded ends, longitudinally striate, 5–6 × 2.5–3 µm	Absent or not observed
F. indica	Hemispherical or pustulate, rounded above, 170–300 × 180–250 µm	Non-cephalothecoid; cells thick-walled, in vertical rows, elongate, 5–7 µm diam.	Fusiform-navicular or rhomboidal, with some furrows, finely striated by irregular, usually longitudinal thickenings, 6–8 × 4–5.5 µm	Arthroconidia, 1–2-celled, hyaline, with truncate ends

mature, one-celled, with longitudinal striations, 5–6 × 2.5–3 µm in frontal view, 2–2.5 µm wide in side view.

Material examined:— **BRAZIL. Pernambuco:** Instituto Agronômico de Pernambuco (IPA), Serra Talhada, in horse dung, 14.II.2013, R.F.R Melo s.n. (URM86672).

Habitat: Recorded on goat dung.

Distribution: Europe (Spain), South America (Brazil). This is the first record from South America.

Notes: *Faurelina hispanica* was described by Valldosera et al. (1987) and distinguished from *F. fimigena* by its smaller ascospores with rounded ends.

Key to species of *Faurelina*

1. Peridium cephalothecoid; ascomata vertically elongate ..... *F. elongata*
Peridium not cephalothecoid; ascomata globose to subglobose 2

2. Conidial state with cylindrical, 0–1-septate arthroconidia; ascospores fusiform–navicular ..... *F. indica*
Conidial state absent or otherwise; ascospores ellipsoidal 3

3. Ascospores 7.5–10 × 4.5–5.5 µm, irregular in shape,
abruptly angular, with tapered ends ..... *F. fimigena*
Ascospores 5–6 × 2.5–3 µm, regular in shape,
phaseoliform to ellipsoidal, with rounded ends ..... *F. hispanica*

Discussion

This study is the first to report *Faurelina* from the Neotropics, expanding its biogeographical distribution. Both species recorded in Brazil are morphologically very similar to the original European descriptions. The other two *Faurelina* species (not yet known from Brazil) were described from Asia: *F. elongata* from Kagoshima (southwestern Kyushu, Japan) and *F. indica* from Delhi (India), both fruiting on herbivore dung.

It is noteworthy that despite the relatively small number of records of this genus worldwide, two *Faurelina* species were recorded in a semi-arid biome. Conservation issues regarding Brazilian semi-arid diversity present a great challenge to taxonomists for a number of reasons, the most significant of which is that with approximately 98% of its territory outside conservation areas, the semi-arid is the least protected natural area in Brazil and suffers from environmental degradation caused by unsustainable use of its natural resources (Leal et al. 2003). Conservation is a major concern of mycologists in the 21st century, who are aware of the significant decline of natural habitats (Moore et al. 2001). The biological diversity in the Caatinga biome is high in relation to what was previously believed. The lack of knowledge about fungal diversity, especially coprophilous fungi, is an important factor that complicates conservation strategies. The focused study of herbivore dung mycobiota can improve the knowledge of the biogeography and diversity of many unreported species.

Acknowledgments

The authors thank José Luiz Bezerra (Universidade Federal do Recôncavo da Bahia, Brazil) and Huzefa A. Raja (University of North Carolina at Greensboro, U.S.A.) for presubmission review.

Literature cited

Benny GL, Kimbrough JW. 1980. A synopsis of the orders and families of *Plectomycetes* with keys to genera. Mycotaxon 12(1): 1–91.

Braga-Neto R, de Giovanni R., Pezzini FF, Canhos DAL, Marino A, Souza S, Maia LC. 2013. Spatial data for fungal specimens: retrospective georeferencing and practical recommendations for mycologists. Mycotaxon 125: 289–301. http://dx.doi.org/10.5248/125.289

Cannon PF, Kirk PM. 2007. Fungal families of the world. CABI, Wallingford.

Leal IR, Tabarelli M, Silva JMC. 2003. Ecologia e conservação da Caatinga. Editora Universitária da UFPE, Recife.

Locquin-Linard M. 1975. *Faurelina*, nouveau genre d'Ascomycètes (*Chadefaudiellaceae*?). Revue de Mycologie 39(2): 125–129.

Moore D, Nauta MM, Evans SE, Rotheroe M. 2009. Fungal conservation: issues and solutions. Cambridge University Press, Cambridge. http://dx.doi.org/10.1017/cbo9780511565168

Parguey-Leduc A, Locquin-Linard M. 1976. L'ontogénie et la structure des périthèces de *Faurelina fimigenes* Locquin-Linard. Revue de Mycologie 40(2): 161–175.

Réblová M, Gams W, Seifert K. 2011. *Monilochaetes* and allied genera of the *Glomerellales*, and a reconsideration of families in the *Microascales*. Studies in Mycology 68: 163–191. http://dx.doi.org/10.3114/sim.2011.68.07

Tang AMC, Jeewon R, Hyde KD. 2007. Phylogenetic utility of protein (RPB2, beta-tubulin) and ribosomal (LSU, SSU) gene sequences in the systematics of *Sordariomycetes* (*Ascomycota, Fungi*). Antonie van Leeuwenhoek 91: 327–349. http://dx.doi.org/10.1007/s10482-006-9120-8

Valldosera M, Guarro J, Figueras MJ. 1987. Coprophilous fungi from Spain VII. *Faurelina hispanica* sp. nov. Mycotaxon 30: 5–7.

von Arx JA. 1978. Notes on *Microascaceae* with the description of two species. Persoonia 10: 23–31.

von Arx JA, Figueras MJ, Guarro J. 1988. Sordariaceous ascomycetes without ascospore ejaculation. Beih Nova Hedwigia 94. 104 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 687–691

http://dx.doi.org/10.5248/131.687

Anaverticicladus uncinatus gen. & sp. nov. from decaying leaves from Brazil

Phelipe M.O. Costa [1], Marcela A. Barbosa [2],
Elaine Malosso [1*] & Rafael F. Castañeda-Ruiz [3]

[1] *Centro de Biociências, Depto de Micologia/Laboratório de Hifomicetos de Folhedo &*
[2] *Programa de Pós-Graduação em Biologia de Fungos,*
Universidade Federal de Pernambuco, Avenida da Engenharia, s/n,
Cidade Universitária, 50740-600, Recife, PE, Brazil
[3] *Instituto de Investigaciones Fundamentales en Agricultura 'Alejandro de Humboldt' (INIFAT),*
Calle 1 Esq. 2, C.P. 17200, Santiago de Las Vegas, C. Habana, Cuba
* Correspondence to: *elaine.malosso@ufpe.br*

Abstract—*Anaverticicladus uncinatus*, collected from decaying leaves in Brazil, is described and illustrated as a new genus and species. It is distinguished by conidiophores that are differentiated, unbranched, erect or prostrate, septate, and pale brown, conidiogenous cells that are monoblastic, terminal, curved to uncinate near the conidiogenous locus, and cylindrical or subulate, and conidia that are solitary cylindrical-fusiform, uncinate, smooth at the base but coarsely verruculose elsewhere, 5–17-euseptate, and golden brown. Conidial secession is schizolytic.

Key words—rainforest, neotropic, taxonomy

Introduction

The diversity of conidial fungi in the Brazilian Atlantic Forest has received little attention (Flora do Brasil 2016). During a survey of hyphomycetes associated with decaying plant materials in Pernambuco State, a conspicuous fungus was collected that shows remarkable differences from all previously described genera (Seifert et al. 2011) and is described here as new.

Materials & methods

Samples of submerged litter were placed in plastic bags for transport to the laboratory, where they were treated according to Castañeda-Ruiz et al. (2016). Attempts

to obtain this species in pure culture were unsuccessful. Mounts were prepared in 90% lactic acid. Anatomical features were measured at a 1000× magnification under a Nikon Eclipse Ni-U microscope using bright field optics and photographed using DIC optics with a Nikon DS-Fi2 digital camera. The holotype was deposited in the Herbarium of Universidade Federal de Pernambuco, Recife, Brazil (URM).

Taxonomy

Anaverticicladus P.M.O. Costa, Malosso & R.F. Castañeda, **gen. nov.**

MycoBank MB 816930

Differs from *Verticicladus* by its unbranched conidiophores, uncinate or curved conidiogenous cells, and schizolytic conidial secession.

Type species: *Anaverticicladus uncinatus* P.M.O. Costa et al.

Etymology: Greek, *ana-*, meaning upwards; Latin *verticicladus* referring to the hyphomycete genus *Verticicladus*.

Asexual fungi. Conidiophores differentiated, erect or prostrate, unbranched, septate, pale brown. Conidiogenous cells monoblastic, curved to uncinate, integrated, determinate. Conidial secession schizolytic. Conidia solitary, acrogenous, cylindrical-fusiform, euseptate, pale brown, subconical truncate at the base.

Anaverticicladus uncinatus P.M.O. Costa, Malosso & R.F. Castañeda, **sp. nov.**

Figs 1–2

MycoBank MB 816931

Differs from all *Verticicladus* spp. by its unbranched slender conidiophores, its uncinate or slightly curved conidiogenous loci, and its euseptate conidia that secede schizolytically.

Type: Brazil, Pernambuco State: Bonito, Mata da Chuva, 8°30′S 35°42′W, on decaying leaves of unidentified plants, 3.III.2016, coll. P.O. Costa (**Holotype**: URM 89939).

Etymology: Latin, *uncinatus*, meaning hook-shaped.

Colonies on the natural substratum effuse, hairy, yellowish-brown. Mycelium mostly superficial, composed of septate, anastomosing or slightly branched, 2–3 µm diam., smooth, pale brown hyphae. Conidiophores differentiated, mononematous, unbranched, erect or prostrate, bent or flexuous, slender, pale brown or brown, subhyaline or very pale brown toward the apex, smooth, 0–3-septate, 40–70 × 3–4 µm. Conidiogenous cells monoblastic, integrated, terminal, determinate, subulate, curved to uncinate near and just before the conidiogenous loci, 15–20 × 3 µm, pale brown. Conidial secession schizolytic. Conidia solitary, acrogenous, 5–17-euseptate, 45–140 × 5–9 µm, cylindrical-fusiform, uncinate or curved at the conical-truncate, smooth-walled basal cell, 7–12 × 2–3 µm, remaining wall verruculose toward the attenuated, narrowly obtuse apex, golden brown, dry.

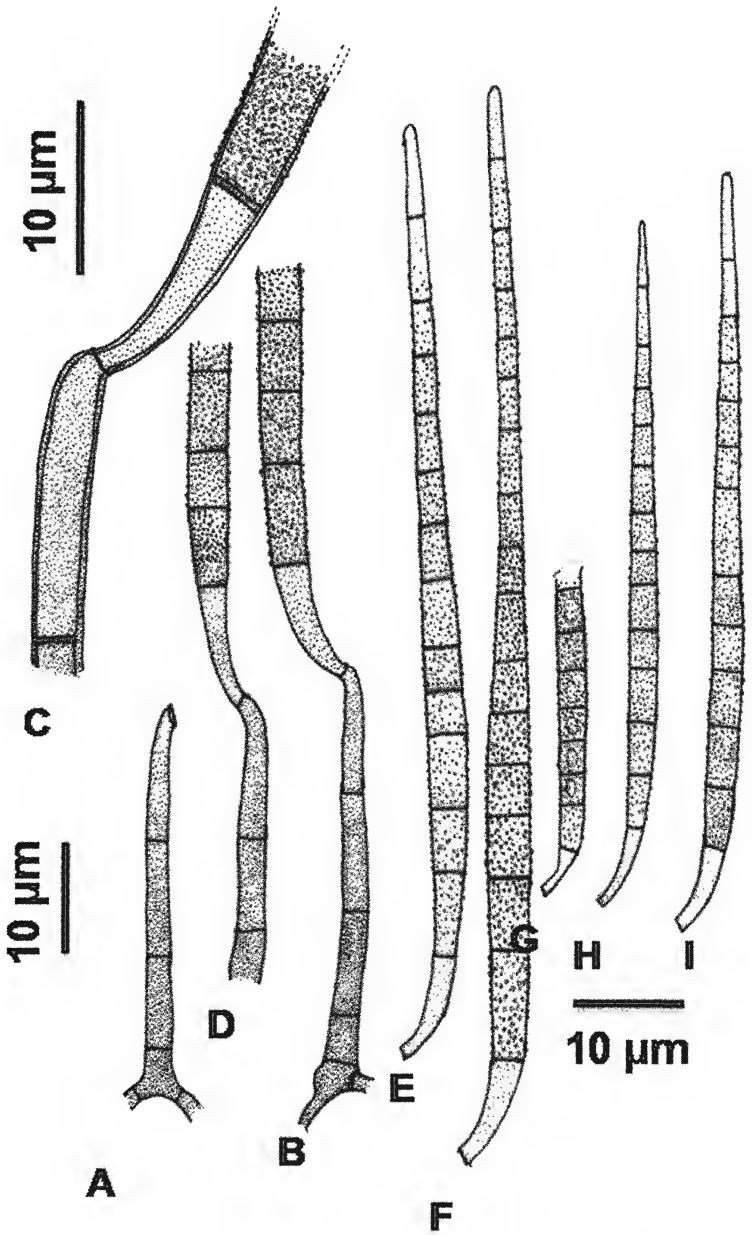


Fig. 1. *Anaverticicladus uncinatus* (ex holotype, URM 89939).
A, B. Conidiophores, conidiogenous cells, and conidium.
C, D. Conidiogenous cells and conidia section. E–I. Conidia.

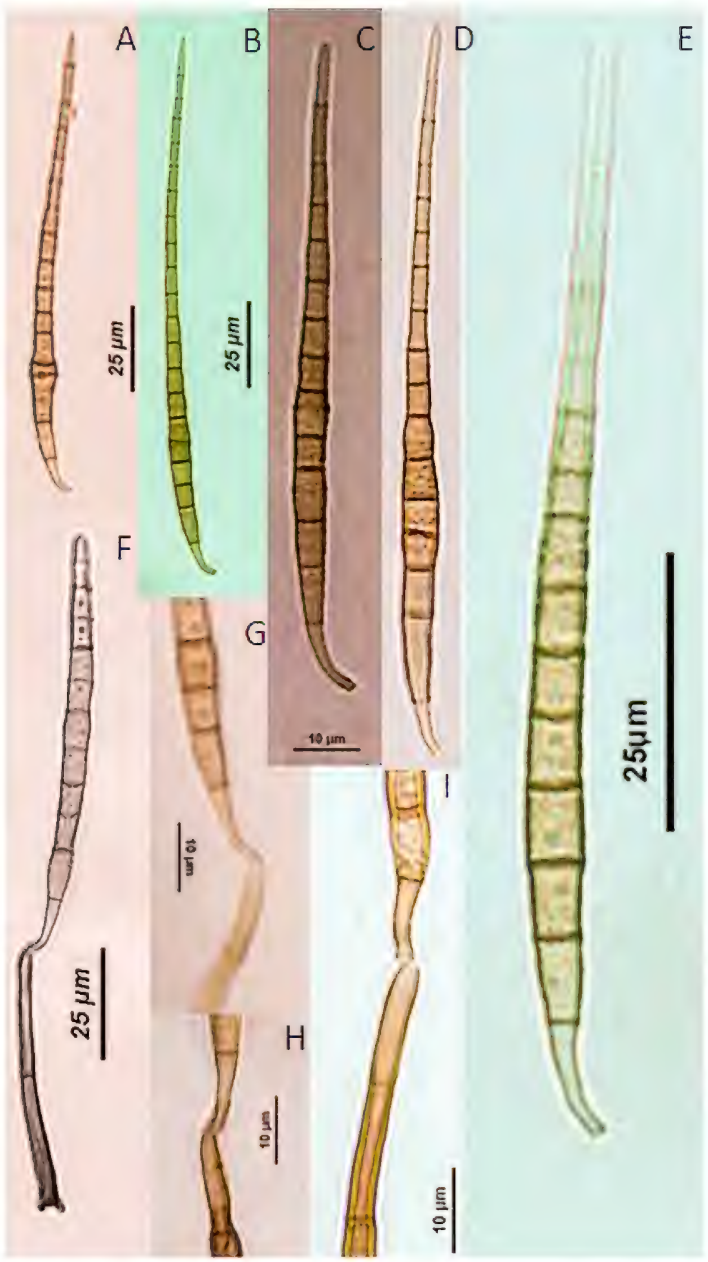


Fig. 2. *Anavericicladus uncinatus* (ex holotype, URM 89939).
A–E. Conidia. F. Conidiophore, conidiogenous cells, and conidium.
G–I. Conidiogenous cells and conidia.

Comments: *Anaverticicladus* is superficially similar to *Mycofalcella* Marvanová et al., *Paraarthrocladium* Matsush., and *Verticicladus* Matsush., all of which have short differentiated conidiophores and a blastic conidial ontogeny but lack uncinate or curved conidiogenous cells near or just before the conidiogenous loci (Seifert et al 2011). *Mycofalcella* is distinguished by reduced unbranched to sparingly branched conidiophores and hyaline scoleco- or phragmoconidia with a basal appendage (Marvanová et al. 1993). *Paraarthrocladium* has unbranched or branched conidiophores, the conidiogenous cells are integrated and determinate or indeterminate with sympodial extensions, and all structures including the conidia are hyaline; and *Verticicladus* is characterized by almost verticillate branched conidiogenous cells and rhexolytic conidial secession (Matsushima 1993).

Acknowledgments

The authors express their sincere gratitude to Dr. De-Wei Li and Dr. Josiane S. Monteiro for their critical review of the manuscript. The authors are grateful to the "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)" for financial support through project 88881.062172/2014-01 and the "Programa Ciência sem Fronteiras." RFCR is grateful to The Cuban Ministry of Agriculture and "Programa de Salud Animal y Vegetal", project P131LH003033 for facilities. We acknowledge the assistance provided by Dr. P.M. Kirk and Dr. V. Robert through the Index Fungorum and MycoBank websites. Dr. Lorelei Norvell's editorial and Dr. Shaun Pennycook's nomenclatural reviews are greatly appreciated.

Literature cited

Castañeda-Ruiz RF, Heredia G, Gusmão LFP, Li DW. 2016. Fungal diversity of Central and South America. 197–217, in: DW Li (ed.). Biology of microfungi. Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-29137-6_9

Flora do Brasil. 2020. <http://floradobrasil.jbrj.gov.br/>. Accessed on 25 April 2016.

Matsushima T. 1993. Matsushima mycological memoirs no. 7. Matsushima Fungus Collection, Kobe, Japan.

Marvanová L, Om-Kalthoum Khattab S, Webster J. 1993. *Mycofalcella calcarata*, anam. gen. et sp. nov. Nova Hedwigia 56: 401–408.

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 693–702

http://dx.doi.org/10.5248/131.693

Morphology and phylogeny of *Cladosporium subuliforme*, causing yellow leaf spot of pepper in Cuba

Beatriz Ramos-García[1], Tomas Shagarodsky[1], Marcelo Sandoval-Denis[2], Yarelis Ortiz[1], Elaine Malosso[3], Phelipe M.O. Costa[3], Josep Guarro[4], David W. Minter[4], Daynet Sosa[6], Simón Pérez-Martínez[7] & Rafael F. Castañeda-Ruiz[1]

[1]*Instituto de Investigaciones Fundamentales en Agricultura Tropical 'Alejandro de Humboldt' (INIFAT), Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200*

[2] *University of the Free State, Faculty of Natural & Agricultural Sciences, Dept. of Plant Sciences, P.O. Box 339, Bloemfontein 9300, South Africa*

[3] *Universidade Federal de Pernambuco, Depto. de Micologia/Laboratório de Hifomicetos de Folhedo, Avenida da Engenharia, s/n, Cidade Universitária, Recife, PE, 50.740-600, Brazil*

[4]*Unitat de Micología, Facultat de Medicina Ciències de la Salut, Universitat Rovira i Virgili, 43201 Reus, Spain*

[5]*CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, United Kingdom*

[6]*Escuela Superior Politécnica del Litoral, ESPOL, CIBE, Km 30.5, Vía Perimetral, Guayaquil, Ecuador*

[7]*Universidad Estatal de Milagro (UNEMI), Facultat de Ingenieria, Milagro, Guayas, Ecuador*

*Correspondence to: *rfcastaneda@inifat.co.cu,rfcastanedaruiz@gmail.com*

Abstract—*Cladosporium subuliforme* is redescribed and illustrated from a specimen collected from yellow leaf spots on pepper (*Capsicum annuum*) cultivated in high tunnels in Cuba. Molecular phylogenetic analyses of morphologically close *Cladosporium* species are provided.

Key words—*Capnodiales*, hyphomycetes, plant disease, taxonomy, tropics

Introduction

Cladosporium Link (Bensch et al. 2010, 2012; Crous et al. 2007; Dugan et al. 2004; Ellis 1971, 1976; Ho et al. 1999; Schubert et al. 2007) typified by *C. herbarum* is a large cosmopolitan hyphomycete genus. IndexFungorum

(2016) lists 777 names for *Cladosporium*, although several species have been transferred to other genera (Bensch et al. 2010, 2012; Crous et al. 2007). Most species are saprobes and can be found in almost all ecological niches and substrates for easy spread through the air where they are common (Ho et al. 1999, Mullins 2001). Some species are pathogenic on cultivated plants (Ellis 1976; McKemy & Morgan-Jones 1990, 1992; Morgan-Jones & McKemy 1992; Schubert & Braun 2004) and a few species are causal agents of human diseases or disorders, mostly as opportunists (Hoog et al. 2011, Sandoval-Denis et al. 2015).

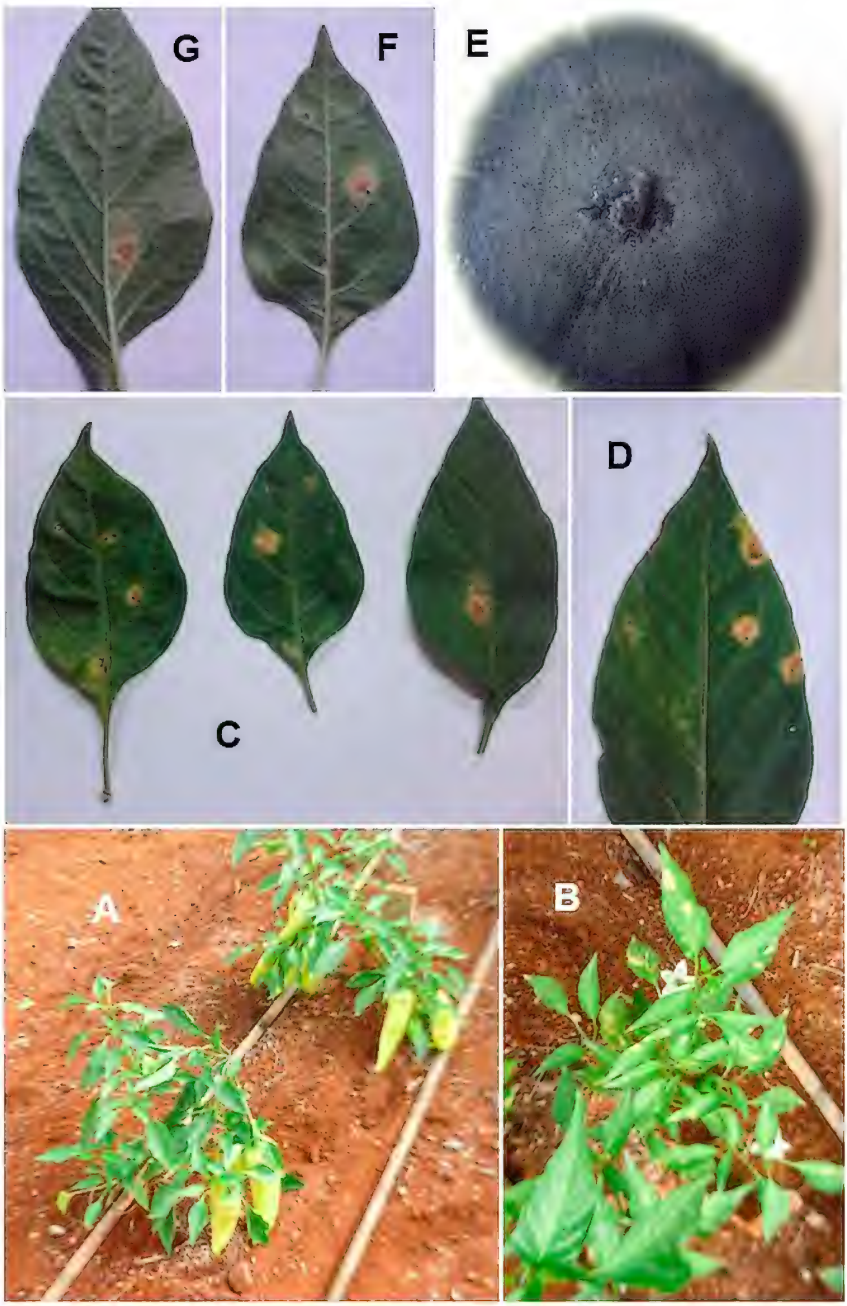
During an inspection of cultivated plants of *Capsicum annuum* (pepper) in high tunnels at the INIFAT Campus, numerous yellow leaf-spotted plants were found associated with a fungus identified as *Cladosporium subuliforme*. The species is redescribed and illustrated below, and phylogenetic analysis of closely related species is provided.

Material & methods

Collection, isolation, and morphology— Samples of leafspots of pepper were collected in high tunnels at the cultivated areas of the INIFAT Campus, Santiago de Las Vegas, Cuba, and placed in paper bags, taken to the laboratory, and processed according to Waller et al. (2002). The fungus was isolated from the substrate using a single conidium isolation technique (Castañeda-Ruiz et al. 2000), grown on oatmeal agar with adjusted pH 6.4, and incubated at 25 °C under alternating cycles of 12 h of daylight and 12 h darkness. Mounts were prepared in PVL (polyvinyl alcohol) and lactic acid and measurements were taken at ×1000. Photomicrographs were obtained with a Zeiss Axio Imager M1 light microscope (Carl Zeiss Meditec, Germany). The pathogenicity test (Koch's postulates) of *C. subuliforme* on pepper plants was confirmed after inoculation of healthy plants with *C. subuliforme* (INIFAT C13/100) following the methodology proposed by Waller et al. (2002). Cultures obtained were deposited in the INIFAT fungus collection, Santiago de Las Vegas, Cuba (INIFAT), in the CBS-KNAW Fungal Biodiversity Centre, Utrecht, the Netherlands (CBS), and in the Faculty of Medicine, Rovira i Virgili University, Reus, Spain (FMR).

DNA extraction, sequencing, and phylogenetic analyses — Total genomic DNA was extracted from mycelia obtained from colonies growing on PDA using FastPrep (MP Biomedicals, Santa Ana, CA) according to the manufacturer's protocol. DNA was quantified using the NanoDrop 3000 (Thermo Scientific, Madrid, Spain). The primers ITS5 and ITS4 (White et al. 1990) were used to amplify the complete ITS

Fig 1. *Cladosporium subuliforme*. A, B. Infected pepper plant growing in a high tunnel; C, D. Collected yellow leafspots on pepper;. E. INIFAT C13/100 colony on oatmeal agar after 10 days; F, G. Yellow leafspots on pepper after pathogenicity test inoculation.


G
F
E
C
D
A
B

(ITS1+5.8S gene+ITS2) rDNA region; the primer pair LR0R/LR5 (Vilgalys & Hester 1990, Rehner & Samuels 1994) was used to amplify a fragment of the large subunit (LSU) rDNA gene; the EF-728F/EF-986R primer pair was used for the translation elongation factor 1α gene (EF-1α) and the ACT-512F/ACT-783R primer pair for the actin gene (Act) (Carbone & Kohn 1999).

Sequencing was performed in both directions using the same PCR primers at Macrogen Europe (Macrogen, Inc., Amsterdam). Consensus sequences were obtained using SeqMan version 7.0.0 (DNASTAR Lasergene, Madison, WI). An initial presumptive generic identification of the isolates was performed based on BLAST searches of ITS and LSU sequences in the GenBank (2016) and CBS (2016) databases. Multiple sequence alignments of each locus were performed in MEGA version6 (Tamura et al. 2013) using the ClustalW application (Thompson et al. 1994), refined with MUSCLE (Edgar 2004), and manually adjusted where necessary. The alignments were complemented with a total of 57 sequences from ex-type or reference strains obtained from GenBank and selected on the basis of the sequence similarity results.

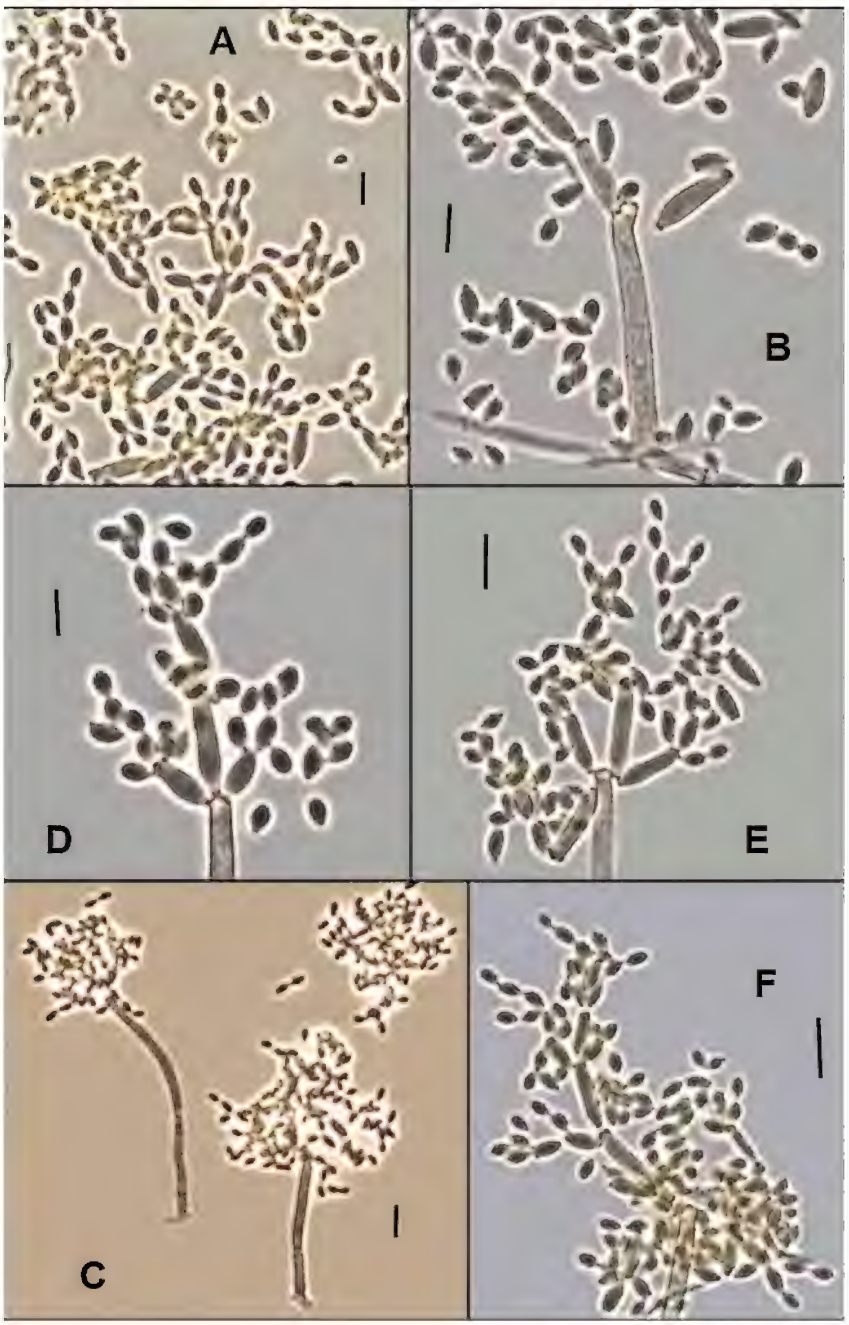
Phylogenetic reconstructions were made using maximum-likelihood (ML; MEGA version 6) and Bayesian Inference (BI; MrBayes version 3.1.2) (Huelsenbeck & Ronquist 2001). The best nucleotide substitution model (generalized time-reversible model with gamma distribution and a portion of invariable sites [GTR+G+I] for the three independent data sets) was estimated using MrModelTest version 2.3 (Nylander 2004) following the Akaike criterion. Phylogenetic analyses using ML were at first made individually for ITS, EF-1α, and Act and compared in order to assess for any incongruent results between nodes with high statistical support. As no incongruences were observed, the three loci were combined. For the ML analysis, nearest-neighbor interchange (NNI) was used as the heuristic method for tree inference. Support for the internal branches was assessed by a search of 1000 bootstrapped sets of data. A bootstrap support value (BS) of ≥70 was considered significant. For BI analysis, two simultaneous runs of 10,000,000 generations were performed, with samples stored every 1000 generations. The 50% majority-rule consensus tree and posterior probability values (PP) were calculated after discarding the first 25% of the samples. A PP value of ≥0.95 was considered significant.

Taxonomy

Cladosporium subuliforme Bensch, Crous & U. Braun, Stud. Mycol. 67: 77. (2010). Figs 1–3

Symptoms on host: subcircular, angular or irregular yellow leaf spot, amphigenous, scattered, slightly necrotic at the centre. Colonies on oatmeal agar floccose, greenish gray to dark greenish olivaceous, margins

Fig 2. *Cladosporium subuliforme* (INIFAT C13/100). A. Ramoconidia and conidia; B, C. Conidiophores, conidiogenous cells, ramoconidia, and conidia; D–F. Conidiogenous cells, ramoconidia, and conidia. Scale bars = 10 μm.


A
B
D
E
C
F

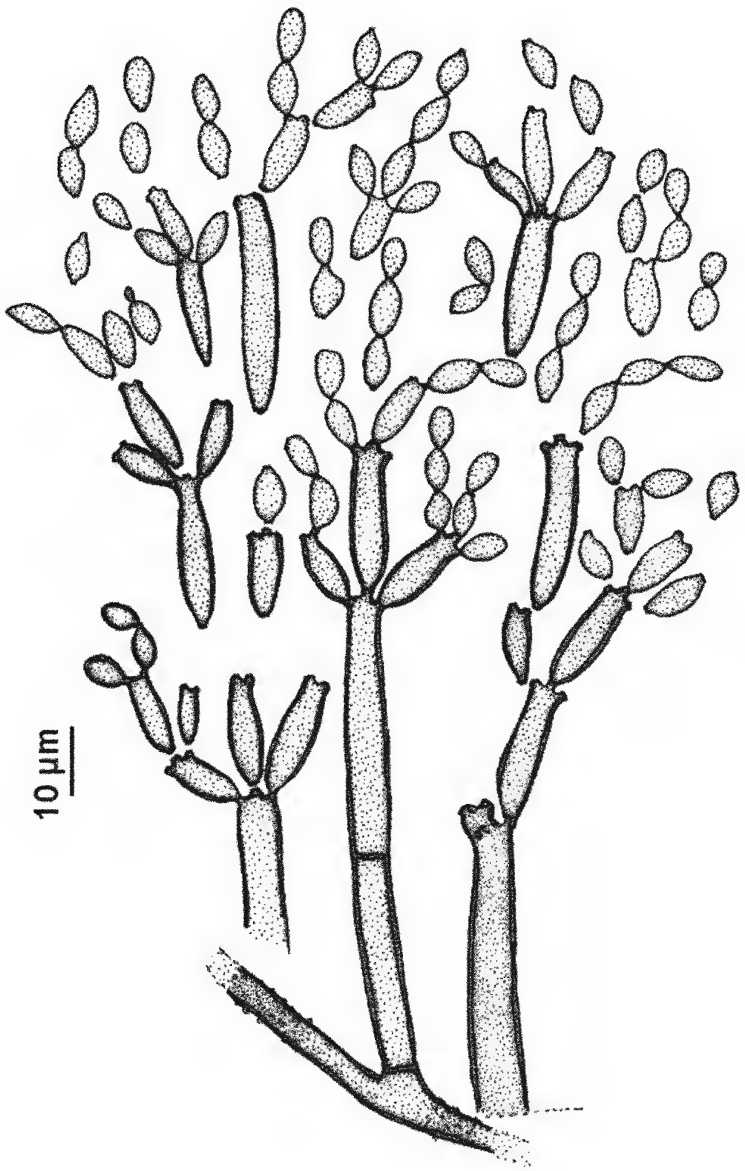


Fig 3. *Cladosporium subuliforme* (INIFAT C13/100).
Conidiophore, conidiogenous cells, ramoconidia, and conidia.

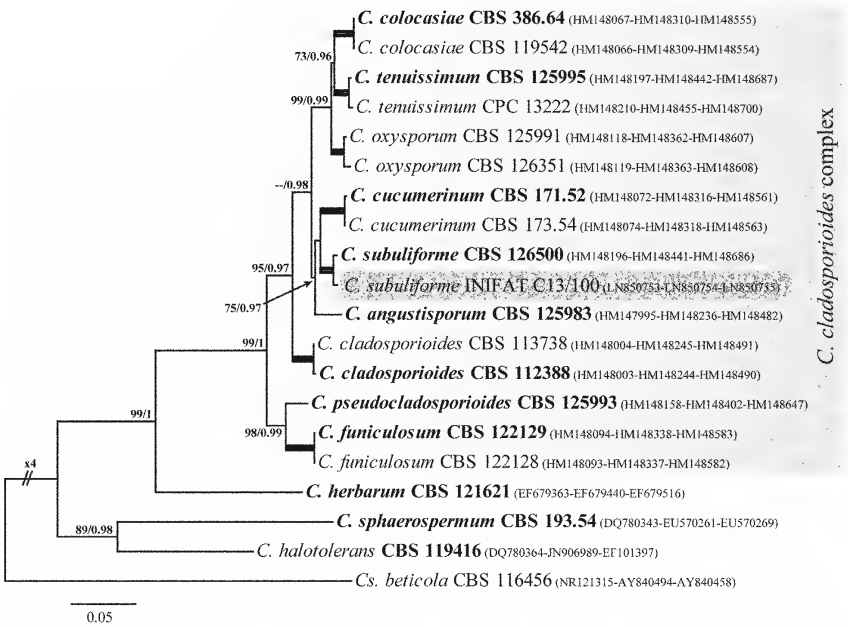


FIG 4. Maximum likelihood tree inferred from combined ITS, EF-1α, and Act sequences showing the phylogenetic relationships between the isolate INIFAT C13/100 and representatives of *Cladosporium* spp. Numbers above the branches are bootstrap values (BS ≥70%) followed by posterior probability values (PP ≥0.95). Fully supported branches (BS 100%/PP 1) are shown in bold. Numbers between parentheses indicate the GenBank accession numbers for the ITS, EF-1α, and Act gene sequences. Sequences from type specimens marked in bold. The scale bar indicates the number of nucleotide substitutions per site. The tree was rooted with *Cercospora beticola* CBS 116456.

pale olivaceous-brown or dull green, after 10 days or pulvinate, scattered, amphigenous, yellow, 300–550 μm diam. Mycelium superficial and immersed, composed of septate, branched, verruculose, pale olivaceous brown hyphae, 2–4 μm diam. CONIDIOPHORES macronematous, branched, erect, straight or flexuous, cylindrical, unbranched or slightly branched toward the apex, septate, olivaceous brown, smooth or verruculose near the base, 40–220 × 2–4 μm. CONIDIOGENOUS CELLS polyblastic, terminal, sometimes intercalary, integrated, cylindrical or oblong, somewhat subnavicular, 12–35 × 4 μm with several thickened and refractive conidiogenous loci, slightly denticulate. Conidial secession schizolytic. RAMOCONIDIA primary and secondary, cuneiform, subcylindrical, subnavicular, truncated at the base, 15–30 × 2–3.5

µm, smooth, olivaceous brown, dry. Conidia blastocatenate, ellipsoidal, ovoid, obovoid to subglobose, forming branched chains, unicellular, smooth, pale olivaceous brown, dry, 3–7 × 3–5 µm, truncated, slightly thickened and refractive at the base or both ends.

Specimen examined: **CUBA. La Habana, Santiago de Las Vegas**, INIFAT Campus, in high tunnels, 22°58′N 82°20′W, on subcircular, angular, or irregular yellow leafspots on *Capsicum annuum* L. (*Solanaceae*), 12-VI-2013, coll. T. Shagarodsky (Live cultures: INIFAT C13/100 = CBS 140073 = FMR 14409; GenBank LN850753, LN850754, LN850755, LN850756).

Note: The Cuban material has shorter ramoconidia and longer conidia than those of the type material (ramoconidia 14–35 µm long; conidia 2.5–12 µm long; Bensch et al. 2012), but otherwise fits well the original description.

Phylogenetic analyses **Fig. 4**

A preliminary identification of the isolate INIFAT C13/100 based on sequence comparison of the ITS and LSU loci showed that it was related with members of the *Cladosporium cladosporioides* complex. However, a species identification was not possible using this approach given the poor resolution of these loci.

A further phylogenetic analysis was performed based on the combined ITS, EF-1α, and Act sequences. The final alignment consisted of a total 973 characters (ITS 443; EF-1α 325; Act 205), of which 378 were variable (ITS 89; EF-1α 186; Act 103) and 182 were informative (ITS 13; EF-1α 105; Act 64). The resulting phylogenetic tree (Fig. 4) showed that INIFAT C13/100 formed a strongly supported monophyletic group with the ex-type strain of *C. subuliforme* (CBS 126500) (BS 100%, PP 1) with a sequence similarity of 100% (ITS), 98.8% (EF-1α), and 98.8% (Act). The clade representing *C. subuliforme* clustered closely related with several species included in the *C. cladosporioides* complex of *Cladosporium*: *C. angustisporum*, *C. cladosporioides*, *C. colocasiae*, *C. cucumerinum*, *C. oxysporum*, and *C. tenuissimum*.

Therefore, the molecular analyses confirmed INIFAT C13/100 identification as *C. subuliforme*. Our phylogeny agrees with previous work on *Cladosporium* (Bensch et al. 2010, 2012); *C. subuliforme* clusters as a phylogenetically well-defined species sister to *C. angustisporum* and *C. cucumerinum*. (*Cladosporium cucumerinum* has also been reported from *Capsicum annuum* in South America; Mendes et al. 1998). However, despite their genetic closeness, the three species are easily differentiated based on the shape and length of their conidiophores and conidia (Bensch et al. 2012). Two other species, *C. cladosporioides* and *C. oxysporum*, also described from *Capsicum* species in South America and Asia (Farr et al. 2016), are also related morphologically and

phylogenetically with *C. subuliforme*. Nevertheless, *C. subuliforme* differs from *C. cladosporioides* by its long and narrow subuliform (subulate) conidiophores, and its narrower conidiogenous loci and conidial hila, and can be distinguished from *C. oxysporum* by its non-nodulose non-geniculate conidiophores (Bensch et al. 2012).

Acknowledgments

The authors express their sincere gratitude to Dr. Xiu-Guo Zhang and Dr. De-Wei Li for their critical review of the manuscript. The authors are grateful to Miss Mirta Caraballo Fernández and Sonia Alvarez for technical assistance. The authors are grateful to the 'Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)' for financial support through project 88881.062172/2014-01 and the 'Programa Ciências em Fronteiras'. RFCR is grateful to the Cuban Ministry of Agriculture and "Programa de Salud Animal y Vegetal", project P131LH003033, for facilities. Dr. Lorelei L. Norvell's editorial review and Dr. Shaun Pennycook's nomenclature review are greatly appreciated.

Literature cited

Bensch K, Groenewald JZ, Dijksterhuis J, Starink-Willemse M, Andersen B, Summerell BA, Shin HD, Dugan FM, Schroers HJ, Braun U, Crous PW. 2010. Species and ecological diversity within the *Cladosporium cladosporioides* complex (*Davidiellaceae*, *Capnodiales*). Studies in Mycology. 67: 1–94. http://dx.doi.org/10.3114/sim.2010.67.01

Bensch K, Braun U, Groenewald JZ, Crous PW. 2012. The genus *Cladosporium*. Studies in Mycology. 72: 1–401. http://dx.doi.org/10.3114/sim0003

Carbone I, Kohn LM. 1999. A method for designing primer set for speciation studies in filamentous ascomycetes. Mycologia 91: 553–556.

Castañeda-Ruiz RF, Iturriaga T, Decock C. 2000. *Bulbocatenospora*, a new hyphomycete genus from Venezuela. Mycological Research 104: 107–109. http://dx.doi.org/10.1017/S095375629900101X

CBS. 2016. http://www.cbs.knaw.nl/ [accessed 16 May 2016].

Crous PW, Braun U, Schubert K, Groenewald JZ. 2007. Delimiting *Cladosporium* from morphologically similar genera. Studies in Mycology. 58: 33–56. http://dx.doi.org/10.3114/sim.2007.58.02

Dugan FM, Schubert K, Braun U. 2004. Check-list of *Cladosporium* names. Schlechtendalia 11: 1–103.

Edgar RC. 2004. MUSCLE: multiple sequence alignment with high accurancy and high throughput. Nucleic Acids Research 32: 4673–4680. http//dx.doi.org/10.1093/nar/gkh340.

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Farr DF, Rossman AY. 2016. Fungal databases, Systematic Mycology and Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases [accessed 25 May 2016]

GenBank. 2016. http://www.ncbi.nlm.nih.gov/ [accessed 16 May 2016]

Ho MHM, Castañeda RF, Dugan FM, Jong SC. 1999. *Cladosporium* and *Cladophialophora* in culture: description and an expanded key. Mycotaxon. 72: 115–157.

Hoog GS de, Guarro J, Gené J, Figueras MJ. 2011. Atlas of clinical fungi, electronic version 3.1. CBS-KNAW Fungal Biodiversity Centre, Utrecht, Netherlands.

Huelsenbeck JP, Ronquist F. 2001. MrBayes: Bayesian inference of phylogenetic trees. Bioinformatics 17: 754–755. http://dx.doi.org/10.1093/bioinformatics/17.8.754

Index Fungorum. 2016 Fungal names search. http://www.indexfungorum.org/names/Names.asp [accessed 16 May 2016]

McKemy JM, Morgan-Jones G. 1990. Studies in the genus *Cladosporium* sensu lato. II. Concerning *Heterosporium gracile*, the causal organism of leaf spot disease of iris species. Mycotaxon. 39: 425–440.

McKemy JM, Morgan-Jones G. 1992. Studies in the genus *Cladosporium* sensu lato. VII. Concerning *Cladosporium cucumerinum*, causal organism of crown blight and scab or gummosis of cucurbits. Mycotaxon. 43: 163–170.

Mendes MAS, da Silva VL, Dianese JC, Ferreira MASV, Santos CEN, Neto EG, Urben AF, Castro C. 1998. Fungos em plants no Brasil. Embrapa-SPI/Embrapa-Cenargen, Brasilia. 555 p.

Morgan-Jones G, McKemy JM. 1992. Studies in the genus *Cladosporium* sensu lato VI. Concerning *Cladosporium vignae*, causal organism of leaf and pod spot of cowpea (*Vignaunguiculata*) and leaf blight of *Lespedeza bicolor*. Mycotaxon. 43: 9–20.

Mullins J. 2001. Microorganisms in outdoor air. 3–16, in: B Flannigan et al. (eds). Microoganisms in home and indoor work environments: diversity, health impacts, investigation and control. Taylor & Francis, London.

Nylander JA. 2004. MrModeltest v2. Evolutionary biology centre, Uppsala University, Uppsala, Sweden.

Rehner SA, Samuels GJ. 1994. Taxonomy and phylogeny of *Gliocladium* analyzed from nuclear large subunit ribosomal DNA sequences. Mycological Research 98: 625–634. http://dx.doi.org/10.1016/S0953-7562(09)80409-7

Sandoval-Denis M, Sutton DA, Martin-Vicente A, Cano-Lira JF, Wiederhold N, Guarro J, Gené J. 2015. *Cladosporium* species recovered from clinical samples in the United States. Journal of Clinical Microbiology 53: 2990–3000. http://dx.doi.org/10.1128/JCM.01482-15

Schubert K, Braun U. 2004. Taxonomic revision of the genus *Cladosporium* s. lat. 2. *Cladosporium* species occurring on hosts of the families *Bignoniaceae* and *Orchidaceae*. Sydowia 56: 296–317.

Schubert K, Groenewald JZ, Braun U, Dijksterhius J, Starink MS, Hill CF, Zalar P, Hoog GS de, Crous PW. 2007. Biodiversity in the *Cladosporium herbarum* complex (*Davidiella*, *Capnodiales*), with standardization of methods for *Cladosporium* taxonomy and diagnostics. Studies in Mycology 58: 105–156. http://dx.doi.org/10.3114/sim.2007.58.05

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S. 2013. MEGA6: Molecular evolutionary genetics analysis version 6.0 Molecular Biology Evolution 30: 2725–2719. http://dx.doi.org/10.1093/molbev/mst197

Thompson JD, Higgins DG, Gibson TJ. 1994. CLUSTALW: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22: 4673–4680. http://dx.doi.org/10.1093/nar/22.22.4673

Vilgalys R, Hester M. 1990. Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. Journal of Bacteriology 172: 4238–4246.

Waller JM, Lenné JM, Waller SJ. 2002. Plant pathologist´s pocketbook (3rd edition). CABI Publishing, Wallingford, UK.

White TJ, Bruns T, Lee S, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. p 315–322, in: MA Innis et al. (eds). PCR protocols: a guide to methods and applications. Academic Press, New York. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 703–715

http://dx.doi.org/10.5248/131.703

Boletus durhamensis sp. nov. from North Carolina

Beatriz Ortiz-Santana [1*], Alan E. Bessette [2] & Owen L. McConnell [3]

[1]*US Forest Service, Northern Research Station, Center for Forest Mycology Research, One Gifford Pinchot Dr., Madison WI 53726*

[2]*170 Live Oak Circle, Saint Marys, GA 31558*

[3]*2808 Butner St., Durham, NC 27704*

* Correspondence to: *bortizsantana@fs.fed.us*

Abstract—A new bolete with cinnamon-brown pores, *Boletus durhamensis*, is described. Collected in northern North Carolina, it is possibly mycorrhizal with *Quercus* spp. Morphological and molecular characters support this taxon as a new species.

Key words—*Boletaceae*, ectomycorrhizal fungi, oaks, taxonomy

Introduction

Studies on boletes in North Carolina started with Coker & Beers (1943). Their work, which was concentrated in the Piedmont area of Orange County, presented morphological descriptions of 68 *Boletus*, four *Boletinus*, and one *Strobilomyces* species. Subsequent studies by Grand (1970a, b, c; 1981), which provided more information about the occurrence, distribution, and host associations of boletes in the mountains and Piedmont regions, added about 10 new records for the state. More recently as part of a workshop devoted to boletes, Justice (2008) listed species from North Carolina based on Bessette et al. (2000) and species reported by the Asheville Mushroom Club and North American Mycological Association's Wildacres Regional Forays.

In 2001, one of us (McConnell) found an unusual brown-capped bolete in a hardwood forest at the Edison Johnson Recreation Center in Durham, NC. The fruiting bodies consistently had brown pore surfaces in all developmental stages, from the very youngest button through maturity. Boletes with brown pore surfaces are rare in North Carolina, and despite careful evaluation of the

unknown bolete's macrofeatures and a search of recent mycological literature, it was not possible to identify the species. Ernst Both (Buffalo Museum of Science, NY) recognized the material as an undescribed species, tentatively naming it "*Boletus durhamensis*" based on its collection locality. Unfortunately, Both died before he was able to publish these findings.

Binion et al. (2008) published one image of *B. durhamensis* with a description (by McConnell), but the name was not validly published under the rules of the International Code of Nomenclature. Since the first collection and description of *B. durhamensis* were obtained when working in collaboration with Ernst Both, and because new collections have been made, his provisional species name is validated here.

Materials & methods

Morphological observation

Macroscopic descriptions are based on fresh and dried specimens, field notes, and color photographs. Color terms are general approximations, while numerical color designations are from Kornerup & Wanscher (1978). Macrochemical reactions were determined using 10% NH_4OH, 5% KOH, and 10% $FeSO_4$. Microscopic structures were observed with an Olympus BH-2 compound microscope; freehand sections of dried fungal material were rehydrated in 70% ETOH and mounted separately in 3% KOH and Melzer's reagent. In the description of basidiospores, *n* = number measured, followed by

Table 1. Taxa included in the study, with their vouchers and GenBank accession numbers. New sequences are indicated with bold font.

Taxon	Voucher	ITS	LSU	TEF
Boletus aereus	REH-8721	—	KF030339	KF030426
	SU07	DQ131619	—	—
B. amygdalinus	112605ba	—	JQ326996	JQ327024
	src491	DQ974705	—	—
B. calopus	Bc1	—	AF456833	JQ327019
	UF1401	HM347645	—	—
B. durhamensis	**BOS-885**	**KM675997**	**KM675998**	—
	Both-4561	**KM675995**	**KM675996**	**KM668212**
B. edulis	BD380	EU231984	HQ161848	—
	Be1	—	—	JQ327018
B. luridus	B12	—	AF139686	—
	AMB12640	KC734544	—	—
B. pinophilus	42/93	—	AF462359	—
	isolate 2163	KC750240	—	—
B. satanas	Bs2	—	AF042015	—
B. subvelutipes	RV98-102	—	AY612804	—
B. tenax	REH-6871	—	KF030320	KF030437

B. variipes	BD245	EU231958	EU232003	—
B. variipes var. *fagicola*	4249	—	JQ327014	JQ327017
	BD190	EU231963	—	—
B. vermiculosus	222/97	—	DQ534646	—
Bothia castanella	MB03-053	—	DQ867117	KF030421
	MB03-067	DQ867114	—	—
B. fujianensis	HKAS-82694	—	KM269193	—
	HKAS-82693	KM269196	—	—
Butyriboletus appendiculatus	Bap1	—	AF456837	JQ327025
	VDK-O429	HQ882194	—	—
B. regius	11265	—	KF030267	KF030411
	MG408a	KC584789	—	—
Caloboletus firmus	MB06-060	—	KF030278	KF030408
	Arora-13039	KM396278	—	—
Sutorius australiensis	REH-9280	—	JQ327005	JQ327031
S. eximius	REH-9400	—	JQ327004	JQ327029
	TH-8988	KT339268	—	—
Tylopilus alboater	TDB-1206	—	AF139708	—
T. appalachiensis	TENN61182	FJ596794	—	—
T. atronicotianus	Both s.n.	EU685114	EU685110	—
T. badiceps	78206	—	KF030335	KF030335
T. felleus	AT2001011	—	JQ326993	JQ327015
	HKAS-55832	—	HQ326934	—
	JMP0093	EU819449	—	—
T. ferrugineus	MB06-053	—	JQ326994	JQ327016
T. indecisus	98-98	—	AF456820	—
T. microsporus	HKAS-59661	—	KF112450	KF112225
T. plumbeoviolaceus	MB06-056	—	KF030350	KF030439
"***T. tabacinus***"	HN-2295	—	AY612837	—
	HN-2295 (CFMR)	**KX925216**	**KX925217**	—
Xerocomellus chrysenteron	HKAS-56494	—	KF112357	KF112172
	TENN60896	FJ596906	—	—
X. cisalpinus	AT2005034	—	KF030354	KF030417
	IB19980850	—	AF514815	—
	PDD94421	—	JQ924322	KF112171
	GS-10020	KT271743	—	—
	BB06304-Bv	HM190074	—	—
X. zelleri	REH-8724	—	KF030271	KF030416
	KGP68	DQ822794	—	—
Xerocomus fennicus	H126	—	AF514820	—
"*X. perplexus*"	MB00-005	JQ003657	JQ003702	KF030438
X. pruinatus	IB19961055	—	AF514825	—
X. riparielus	GR22465	—	AF514818	—
X. subtomentosus	strain Xs1	—	AF139716	JQ327035
	1549a-Q-6103	KM248935	—	—
Chalciporus piperatus	MB 04-001	—	DQ534648	GU187690
	2591	KM248949	—	—
C. pseudorubinellus	4302	—	KF030287	KF030441
C. rubinellus	2626	KM248951	—	—

the mean basidiospore lengths and widths ± their standard deviations and the Q_m value, which represents the mean Q value ± its standard deviation, where Q = length/width ratio. Specimens examined are deposited in the CFMR herbarium. Herbarium acronym follows Thiers (2016).

DNA extraction, PCR & sequencing

DNA sequences from two nuclear ribosomal DNA regions (LSU and ITS) and one protein-coding gene (TEF1-alpha) of *B. durhamensis* were generated in the present study. DNA extraction, amplification, and sequencing from dried specimens of *B. durhamensis* were conducted at the Center for Forest Mycology Research in Madison, following Palmer et al. (2008). The ITS region was amplified with primers ITS1F (Gardes & Bruns 1993) and ITS4 (White et al. 1990), the 5′ end of the LSU region was amplified using primer pair LROR/LR5 (Vilgalys & Hester 1990) and TEF1 was amplified using primer pair EF1-983/EF1-1567R (Rehner & Buckley 2005). For TEF PCR protocols see Minnis & Lindner (2013).

Phylogenetic analysis

DNA sequences were used primarily for molecular identification and were compared with other sequences available in GenBank via BLASTn search (Benson et al. 2013). DNA sequences were also used to infer the phylogenetic relationship among *B. durhamensis* and other members of the family *Boletaceae*. Considering the BLASTn search results and the main morphological characters of *B. durhamensis*, sequences of species pertaining to the genera *Boletus*, *Bothia*, *Butyriboletus*, *Caloboletus*, *Sutorius*, *Tylopilus*, *Xerocomellus,* and *Xerocomus* were retrieved from GenBank (Table 1). *Chalciporus piperatus* (Bull.) Bataille, *C. pseudorubinellus* (A.H. Sm. & Thiers) L.D. Gómez, and *C. rubinellus* (Peck) Singer were used as outgroup in the phylogenetic analyses. Sequences were edited with Sequencher 4.8 (Gene Codes Corp., Ann Arbor, Michigan), and aligned using MAFFT v.7 (Katoh & Standley 2013). The alignment was manually adjusted using MacClade 4.08 (Maddison & Maddison 2002). ITS, LSU, and TEF datasets were compiled and evaluated with Maximum likelihood (ML) analysis run in RAxML server, v.7.7.1 (Stamatakis et al. 2008) under GTR GAMMA model with 100 rapid bootstrap replicates.

Taxonomy

Boletus durhamensis B. Ortiz, Bessette & McConnell, **sp. nov.** Plates 1–2

MycoBank MB 810115

Differs from *Boletus vermiculosoides* and *B. vermiculosus* by its lack of a bluing reaction when its flesh is exposed, its partial veil covering the immature pores, and its smaller basidiospores.

Type: USA. North Carolina: Durham Co., Edison Johnson Recreational Center, 11 August 2001, O.L. McConnell, Both 4561 (**Holotype**, CFMR, GenBank KM675995, KM675996, KM668212).

Etymology: *durhamensis* refers to Durham, North Carolina, where this bolete was first collected by mycologist Owen L. McConnell.

PLATE 1. *Boletus durhamensis* (BOS 885). Basidiomata. Photo by OL McConnell.

ICONES: Macrofungi associated with oaks of eastern North America (Binion et al. 2008: 48).

PILEUS 4–8 cm diam., hemispherical at first, becoming convex to broadly convex at maturity; surface dry, subtomentose to subvelutinous, medium brown to cinnamon-brown (near 5D7-5D5), becoming paler brown to yellowish brown (near 4B6) in age; margin incurved when young, typically yellowish, with a slight overlapping band of sterile tissue. FLESH white, slightly tinged with yellowish tan, unchanging when exposed; odor pleasant and somewhat fruity when fresh, strong and disagreeable in dried specimens; taste not distinctive. HYMENOPHORE tubular; tubes 2–6 mm deep, straw-colored (near 3B4), not staining when bruised but becoming brown in dried specimens (6D7); pores 2–3 per mm in immature specimens, ≤1 mm diam. in mature specimens; pore surface adnate to narrowly depressed near the stipe, uniformly deep cinnamon-brown (near 6D6) in mature specimens, unchanging or slightly darker brown when bruised; pores in immature specimens covered by a layer of whitish hyphae (partial veil or conspicuously developed cheilocystidia), this layer becoming greyish yellow (4B4-4C4) in dried specimens. STIPE 2.8–7.5 cm long, 1–2 cm broad, nearly equal or slightly enlarged downward, solid; surface dry and smooth, with a very pale yellow ground color (3A3-4B3) that typically becomes covered with cinnamon-brown (near 6D6) pruinosity, the pruinosity being sparse on young boletes and heavier on mature ones, and the stipe sometimes becoming vertically streaked with pruinosity; true reticulation

is often absent on young specimens, and when found on older stipes consisting of a fine network typically restricted to the uppermost centimeter or two. Basal mycelium white. Stipe flesh solid, concolorous with the pileal flesh. Spore print olivaceous gray-brown (near 4D7) or olive-brown in fresh deposit.

Basidiospores 8.1–10.8 × 3.6–4.5 µm (n = 30, 9.33 ± 0.96 × 3.9 ± 0.35 µm; Q_m = 2.40 ± 0.15), fusoid to subcylindrical, smooth, grayish yellow in KOH; pale yellowish or with brighter wall in Melzer's. Basidia 22.5–27 (–41.4) × 7.2–8.1 µm, mostly clavate, few cylindro-clavate (2) 4-sterigmate, hyaline in KOH. Basidioles 18–27(–38.7) × 6.3–8.1 µm, mostly clavate. Pleurocystidia 24.3–48.6 × 5.4–11.7 µm, most frequently lageniform, but also fusoid to fusoid-ventricose or ventricose-rostrate, few cylindric, mostly with rounded tip, smooth and thin-walled, hyaline or with yellow contents in KOH, non-reactive in Melzer's. Cheilocystidia 22.5–52.2 × 5.4–9 µm, fusoid, ventricose-rostrate, smooth, thin-walled, hyaline or with pale yellow contents in KOH, non-reactive in Melzer's; terminal elements covering the immature pores longer, 45–78.3 × 5.4–8.4 µm, cylindrical to sub-constricted, hyaline in KOH, non-reactive in Melzer's. Pileipellis a tangled layer of erect to repent hyphae, 3.6–7.2 µm diam., hyaline to grayish yellow in KOH; end cells cylindrical. Pileus trama hyphae moderately to tightly interwoven, 4.5–19.8 µm diam., hyaline in KOH, non-reactive in Melzer's, smooth, thin-walled. Stipitipellis hyphae 3.6–11.7 µm diam., parallel to subparallel to interwoven, hyaline in KOH, yellowish in Melzer's. Caulocystidia 27–97.2 × 6.3–9 µm, clavate, fusoid, cylindrical, sub-lageniform, in clusters (fasciculate), hyaline in KOH, yellowish in Melzer's, thin-walled. Dermatobasidia present, 19.8–28.8 × 7.2–9 µm, hyaline in KOH, contents non-dextrinoid to weakly dextrinoid in Melzer's. Clamp connections absent.

Macrochemical reactions: Pileipellis staining red-orange with KOH, slightly dull vinaceous with NH_4OH, and negative with $FeSO_4$; flesh not reacting (negative) with KOH, NH_4OH, and $FeSO_4$.

Ecology & distribution: solitary, scattered, or in groups on the ground in a sparsely grassy area near a mixed broadleaf woods with willow oak (*Quercus phellos*), white oak (*Quercus alba*), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and dogwood (*Cornus florida*); August; reported only from the eastern Piedmont of North Carolina.

Additional specimens examined: **USA. North Carolina: Granville Co.**, Town of Butner, John Umstead Hospital picnic area, under white oak, 29 July 2014, O.L. McConnell BOS 885 (CFMR; GenBank KM675997, KM675998); **Durham Co.**, Edison Johnson Recreational Center, under willow oak, 7 August 2014, O.L. McConnell BOS 886 (CFMR); Duke Forest Jogging Trail, October 1993, HN 2295 (DUKE, as "*Tylopilus tabacinus*").

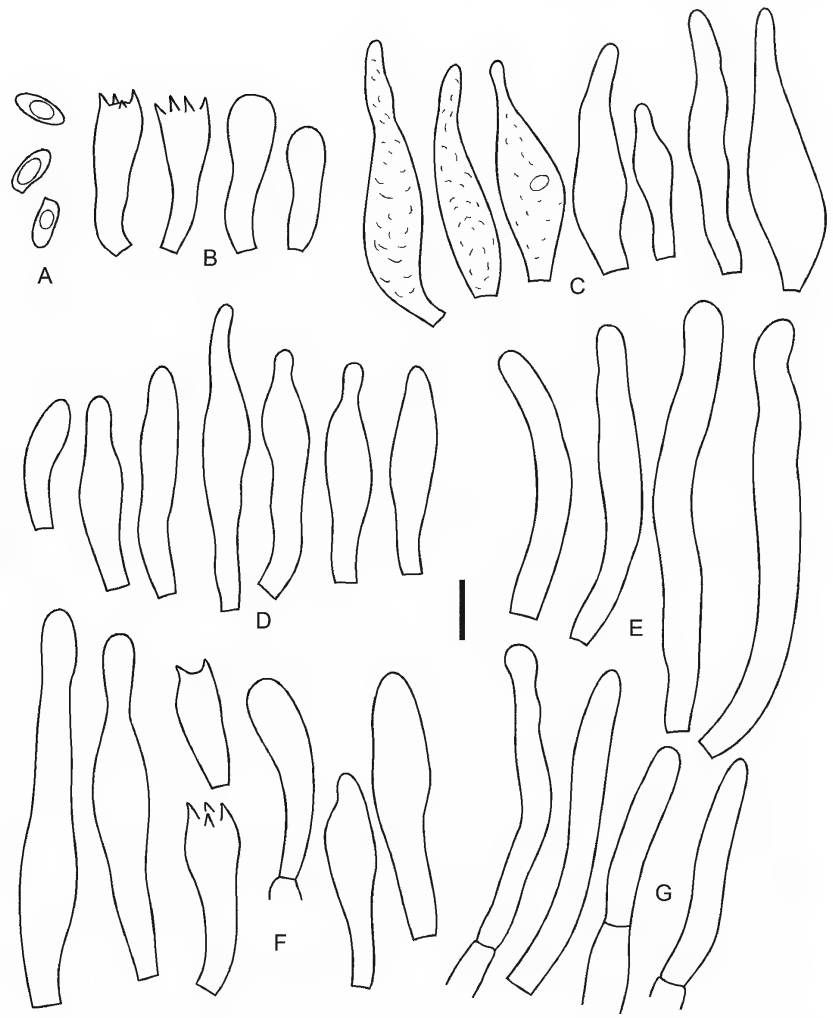


Plate 2. *Boletus durhamensis* (holotype Both 4561; BOS 855). A. basidiospores; B. basidia and basidioles; C. pleurocystidia, some with yellow contents; D. cheilocystidia; E. cheilocystidia covering the immature pores; F. caulocystidia and dermatobasidia; G. terminal elements of the pileipellis. Scale bar = 10 µm.

Additional characters of *B. durhamensis* based on dried specimens of collection HN 2295 (initially misidentified as "*Tylopilus tabacinus*"): Pileus ≤12 cm diam., plane, uplifted, smooth to finely velutinous, pale brownish orange (5C5). Flesh cream. Tubes ≤11 mm deep, cinnamon-brown to raw sienna (6D7); pores

1–2 per mm yellowish brown (5D8), adnate to decurrent. Stipe 10 cm long, 3.5 cm diam., concolorous with pileus; finely reticulate at apex (11 mm from apex), otherwise smooth; caespitose. Basidiospores 9–10.8 × 3.6–4.5 µm, fusoid, smooth. Basidia 20.7–26 × 8.1–9 µm, clavate, 4-sterigmate, hyaline in KOH. Pleurocystidia 49.5–62.1 × 9–9.9 µm, most frequently lageniform. Cheilocystidia 24.3–31.5 × 6.3–9.9 µm, fusoid, ventricose-rostrate.

Comments—The cinnamon-brown or brown pores would place *B. durhamensis* in *Boletus* sect. *Luridi* (Singer 1986), while the presence of a hyphal layer covering the immature pores (partial veil) and lack of any bluing reaction would place it in *B.* sect. *Boletus* (Singer 1986). Within *B.* sect. *Luridi*, a brown pore surface is also found in *B. vermiculosoides* A.H. Sm. & Thiers and *B. vermiculosus* Peck, which differ by turning blue when their flesh is exposed, the absence of a partial veil covering the immature pores, and their larger basidiospores. Within *B.* sect. *Boletus*, the presence of the partial veil on immature pores is shared with several species including *B. aereus* Bull., *B. edulis* Bull., *B. pinophilus* Pilát & Dermek, and *B. variipes* Peck, all of which can be distinguished from *B. durhamensis* by their possession of a true reticulum and larger basidiospores.

The presence of the partial veil covering the immature pores is also found in *Butyriboletus* (*Boletus* sect. *Appendiculati* Lannoy & Estadès; Šutara 2014). Šutara (2014), who refers to this veil as a layer of conspicuously developed cheilocystidia, indicates its presence in several *Butyriboletus* species: *B. appendiculatus* (Schaeff.) D. Arora & J.L. Frank, *B. fechtneri* (Velen.) Arora & J.L. Frank, *B. regius* (Krombh.) Arora & J.L. Frank, *B. roseogriseus* (J. Šutara et al.) Vizzini & Gelardi, and *B. subappendiculatus* (Dermek et al.) Arora & J.L. Frank. Šutara also mentions that it is not clear whether this cheilocystidia arrangement also occurs in American and Chinese *Butyriboletus* species, since neither Arora & Frank (2014) nor Li et al. (2014) mention it in their descriptions. When comparing *Butyriboletus* species with *Boletus durhamensis*, we found that most of those species have pileus with reddish tones, a yellow hymenophore that turns blue after bruising, and a stipe finely or strongly reticulate with reddish tones, and somewhat larger basidiospores. Other species that also appear to have this partial veil are *Sutorius australiensis* (Bougher & Thiers) Halling & N.A. Fechner and *S. eximius* (Peck) Halling et al.; however both species differ from *B. durhamensis* in their overall basidiocarp colors (which range from reddish brown to purple brown and dark gray), ornamented stipes, reddish brown spore print color, and larger basidiospores (Bessette et al. 2000, Halling et al. 2012).

BLASTn searches on GenBank were performed independently with the newly generated sequences. ITS and TEF BLASTn queries of *B. durhamensis*

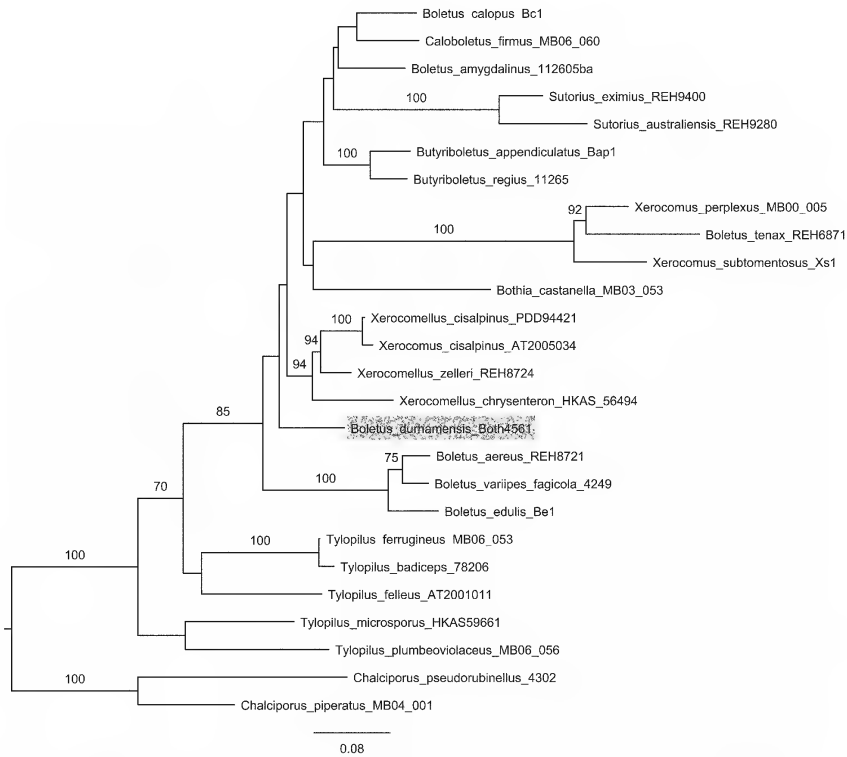


FIGURE 1. ML tree based on TEF sequences. Bootstrap values >70% are included above branches.

were uninformative at the generic level, with none of the searches exceeding 95% similarity with any available sequence. The nearest matches obtained were isolates representing the genus *Xerocomellus*. When comparing LSU sequences, the closest matches found were a sequence labelled as "*Tylopilus tabacinus*" (isolate HN2295) and a sequence of *Xerocomellus fennicus* (Harmaja) Šutara (isolate H126). In view of the search results and certain morphological characters (e.g., spore print color, presence of partial veil on immature pores), different bolete taxa were selected for additional sequence analyses to test the relationship of *B. durhamensis* with other boletes.

The phylogenetic relationship was inferred using three different datasets (ITS, LSU, TEF) and one phylogenetic analysis (ML). Results were based on the topology of the best-scoring ML tree. Datasets comprised: (ITS) 26 ingroup sequences, 578 characters; (LSU) 42 ingroup sequences, 875 characters;

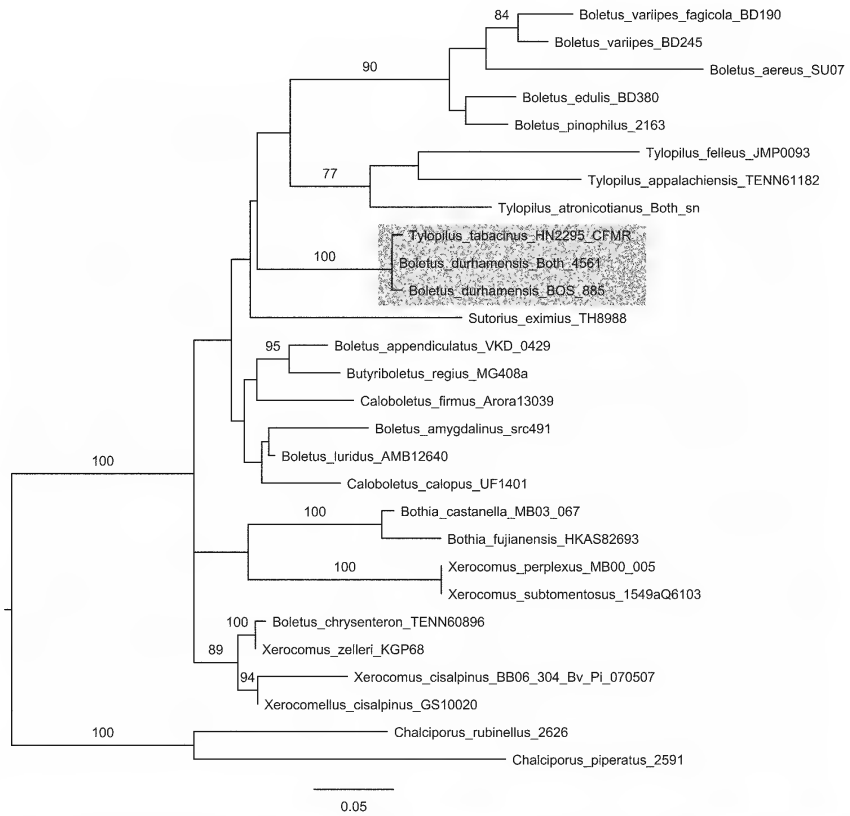


FIGURE 2. ML tree based on nrITS sequences. Bootstrap values >70% are included above branches.

(TEF) 24 ingroup sequences, 592 characters. The TEF analysis (FIG. 1) placed *B. durhamensis* on an independent branch within a moderately supported clade comprising species of *Boletus* s.s., *Bothia*, *Butyriboletus*, *Caloboletus*, *Sutorius*, *Xerocomellus*, and *Xerocomus;* this clade appears as a sister clade of *Tylopilus* s.s. The ITS and LSU analyses (FIGS. 2, 3) clustered *B. durhamensis* with isolates labelled as "*Tylopilus tabacinus*" (HN2295) in an independent clade and not grouping with any of the other bolete genera mentioned above.

Because of the similarity of these LSU sequences, we obtained the specimen of HN2295, which we examined morphologically and from which we generated ITS and LSU sequences. Comparison of the morphological and sequence data confirms that *B. durhamensis* and HN2295 are similar and that neither

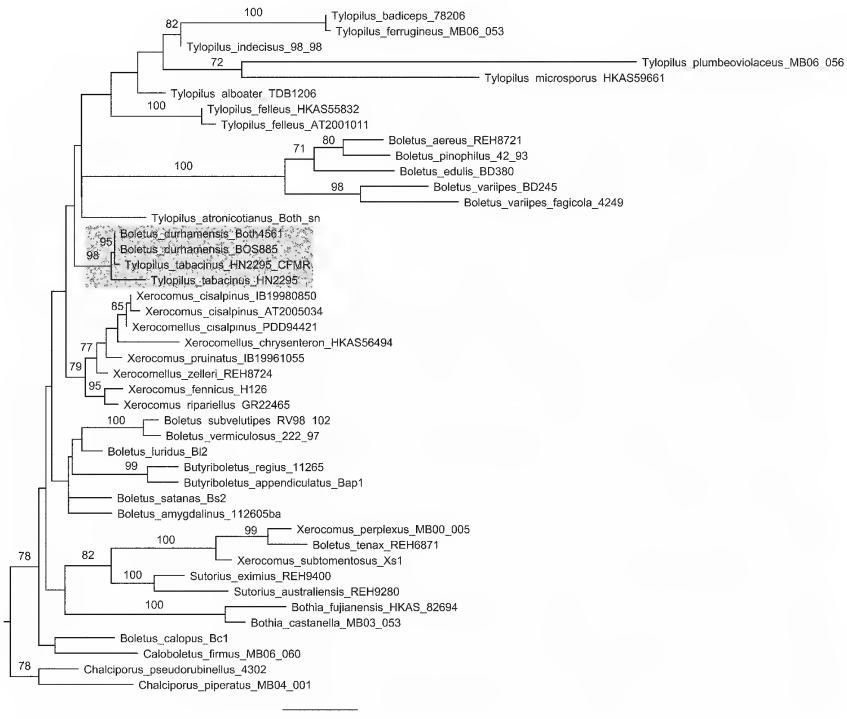


FIGURE 3. ML tree based on nrLSU sequences. Bootstrap values >70% are included above branches.

collection belongs to the genus *Tylopilus* or represents *Tylopilus tabacinus* (Peck) Singer. Although similar to *B. durhamensis* in basidiocarp color and overall appearance, *T. tabacinus* produces a pinkish brown to reddish brown spore deposit, is often prominently reticulate over much of the stipe, has bitter tasting flesh (Singer 1947), its pleurocystidia are dextrinoid in Melzer's (Smith & Thiers 1971), and it lacks cheilocystidia (Wolfe 1981).

Our phylogenetic analyses confirmed the results obtained through BLASTn searches that *B. durhamensis* seems to be unrelated to any genus in the *Boletaceae* currently represented in GenBank. Nonetheless, since several of its morphological characteristics resemble species of *Boletus* s.l., we propose its placement within *Boletus*. Recent molecular studies (Dentinger et al. 2010, Nuhn et al. 2013, Wu et al. 2014) have demonstrated that several bolete genera (e.g., *Boletus*, *Tylopilus*, and *Xerocomus*) are not monophyletic, and the creation

of new genera may differentiate the well-supported groups obtained within each of them. Therefore, we suggest that more molecular data are still needed to clarify the evolutionary relationship and history within *Boletaceae*. Not all the described bolete species have been studied from a molecular perspective, and there are characteristics, such as the partial veil on the immature pores or the brown pore surface, that appear to have evolved independently in several different lineages of the family. In conclusion, further molecular studies of boletes are needed to determine whether *B. durhamensis* should remain in *Boletus* or be transferred to a new and as yet undescribed genus.

Acknowledgements

The authors are very grateful to Drs. Roy E. Halling and Alfredo Justo for critical review of the manuscript; we also thank Drs. D. Jean Lodge and Andrew M. Minnis for valuable comments on an earlier version of the manuscript.

Literature cited

Arora D, Frank JL. 2014. Clarifying the butter boletes: a new genus, *Butyriboletus*, is established to accommodate *Boletus* sect. *Appendiculati*, and six new species are described. Mycologia 106: 464–480. http://dx.doi.org/10.3852/13-052

Benson DA, Cavanaugh M, Clark K, Karsch-Mizrachi I, Lipman DJ, Ostell J, Sayers EW. GenBank. 2013. Nucleic Acids Research. 41: D36-D42. http://dx.doi.org/10.1093/nar/gks1195

Bessette AE, Roody WC, Bessette AR. 2000. North American boletes: a color guide to the fleshy pored mushrooms. Syracuse University Press, USA. 396 p.

Binion DE, Stephenson SL, Roody WC, Burdsall HH Jr, Vasilyeva N, Miller OK Jr. 2008. Macrofungi associated with oaks of eastern North America. West Virginia University Press. 467 p.

Coker WC, Beers AH. 1943. The Boletaceae of North Carolina. University of North Carolina Press, Chapel Hill, USA.

Dentinger BTM, Ammirati JF, Both EE, Desjardin DE, Halling RE, Henkel TW, Moreau PA, Nagasawa E, Soytong K, Taylor AF, Watling R, Moncalvo JM, McLaughlin DJ. 2010. Molecular phylogenetics of porcini mushrooms (*Boletus* section *Boletus*). Molecular Phylogenetics and Evolution 57: 1276–1292. http://dx.doi.org/10.1016/j.ympev.2010.10.004

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. http://dx.doi.org/10.1111/j.1365-294X.1993.tb00005.x

Grand LF. 1970a. Notes on North Carolina boletes. I. Species of *Boletellus*, *Phylloporus*, *Strobilomyces*, *Tylopilus*, and *Xanthoconium*. Journal of the Elisha Mitchell Scientific Society 86: 49–56.

Grand LF. 1970b. Notes on North Carolina boletes. II. Species of *Gyrodon, Gyroporus, Xerocomus,* and *Leccinum*. Journal of the Elisha Mitchell Scientific Society 86: 57–61.

Grand LF. 1970c. Notes on North Carolina boletes. III. Species of *Suillus*. Journal of the Elisha Mitchell Scientific Society 86: 209–213.

Grand LF. 1981. Notes on North Carolina boletes. IV. New species and distribution of *Suillus*. Journal of the Elisha Mitchell Scientific Society 97: 204–208.

Halling RE, Nuhn M, Fechner NA, Osmundson TW, Soytong K, Arora D, Hibbett DS, Binder M. 2012. *Sutorius*: a new genus for *Boletus eximius*. Mycologia 104: 951–961. http://dx.doi.org/10.3852/11-376

Justice J. 2008. Bolete workshop. http://www.ashevillemushroomclub.com/docs/key-Justice-bolete.pdf

Katoh K, Standley DM. 2013. MAFFT Multiple Sequence Alignment Software Version 7: Improvements in Performance and Usability. Molecular Biology and Evolution 30: 772–780. http://dx.doi.org/10.1093/molbev/mst010

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. 3rd ed., reprinted. Eyre Methuen Ltd., London. 252 p.

Li H, Wei H, Peng H, Wang L, He L, Fu L. 2014. *Boletus roseoflavus*, a new species of *Boletus* in section *Appendiculati* from China. Mycological Progress 13: 21–31. http://dx.doi.org/10.1007/s11557-013-0888-4

Maddison DR, Maddison WP. 2002. MacClade4: Analysis of phylogeny and character evolution. Sunderland, Massachusetts: Sinauer.

Minnis AM, Lindner DL. 2013. Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. nov., in bat hibernacula of eastern North America. Fungal Biology 117: 638–649. http://dx.doi.org/10.1016/j.funbio.2013.07.001

Nuhn M, Binder M, Taylor A, Halling R, Hibbett D. 2013. Phylogenetic overview of the *Boletineae.* Fungal Biology 117: 479–511. http://dx.doi.org/10.1016/j.funbio.2013.04.008

Palmer JM, Lindner DL, Volk TJ. 2008. Ectomycorrhizal characterization of an American chestnut (*Castanea dentata*) -dominated community in Western Wisconsin. Mycorrhiza 19: 27–36. http://dx.doi.org/10.1007/s00572-008-0200-7

Rehner SA, Buckley E. 2005. A *Beauveria* phylogeny inferred from nuclear ITS and EF1-α sequences: evidence for cryptic diversification and links to *Cordyceps* teleomorphs. Mycologia 97: 84–98. http://dx.doi.org/10.3852/mycologia.97.1.84

Singer R. 1947. The *Boletoideae* of Florida. The *Boletineae* of Florida with notes on extralimital species III. American Midland Naturalist 37: 1–135. http://dx.doi.org/10.2307/2421647

Singer R. 1986. The *Agaricales* in modern taxonomy. 4th ed. Koeltz Scientific Book, Koenigstein.

Smith AH, Thiers HD. 1971. The boletes of Michigan. University of Michigan Press, Ann Arbor, USA.

Stamatakis A, Hoover P, Rougemont J. 2008. A rapid bootstrap algorithm for the RAxML web-servers. Systematic Biology 75: 758–771. http://dx.doi.org/10.1080/10635150802429642

Šutara J. 2014. Anatomical structure in European species of genera *Boletus* s.str. and *Butyriboletus* (*Boletaceae*). Czech Mycology: 66: 157–170.

Thiers B. 2016. [continually updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. [Accessed: September/2014 http://sciweb.nybg.org/science2/IndexHerbariorum.asp]

Vilgalys R, Hester M. 1990. Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. Journal of Bacteriology 172: 4238–4246.

White TJ, Bruns T, Lee SS, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis et al. (eds). PCR protocols: A guide to methods and applications. New York: Academic Press. http://dx.doi.org/10.1016/B978-0-12-372180-8.50042-1

Wolfe CB Jr. 1981. Type studies in *Tylopilus*. I. Taxa described by Charles H. Peck. Sydowia 34: 199–213.

Wu G, Feng B, Xu J, Zhu XT, Li YC, Zeng NK, Hosen MI, Yang ZL. 2014. Molecular phylogenetic analyses redefine seven major clades and reveal 22 new generic clades in the fungal family *Boletaceae*. Fungal Diversity 69: 93–115. http://dx.doi.org/10.1007/s13225-014-0283-8

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 717–721

http://dx.doi.org/10.5248/131.717

Diorygma fuscum sp. nov. from China

Jian Li & Ze-Feng Jia*

College of Life Sciences, Liaocheng University, Liaocheng, 252059, China

* Correspondence to: *zfjia2008@163.com*

Abstract—A new lichen species, *Diorygma fuscum*, is described from Fujian Province, China. It is characterized by the conspicuous open immersed lirellae with densely white pruinose discs, the hyaline to brownish muriform ascospores sized 40–60 × 12–18 µm, and the presence of stictic acid. The type specimen is deposited in HMAS-L.

Key words—*Ascomycota*, *Ostropales*, *Graphidaceae*, taxonomy

Introduction

Diorygma Eschw. (*Graphidaceae*) is mainly a tropical to subtropical genus (Staiger 2002; Kalb et al. 2004), characterized by its inconspicuous pseudocortex, lirellate ascocarps with a pruinose disc, branched or anastomosing paraphyses with a thick gelatinous wall, *Graphis*-type 1–8-spored asci, ascospores that are transversely septate with lenticular spore locules or muriform, and the presence of norstictic, stictic, and/or protocetraric acid. At present, more than 50 species are known worldwide (Kalb et al. 2004; Cáceres 2007; Archer 2009; Makhija et al. 2009; Sharma & Makhija 2009a, b; Sharma & Khadilkar 2012; Lima et al. 2013; Feuerstein et al. 2014; Sutjaritturakan et al. 2014).

Nine *Diorygma* species have been reported from China: *D. hieroglyphicum*, *D. hololeucum*, *D. junghuhnii* [= *Graphina mendax*], *D. macgregorii*, *D. megasporum*, *D. pachygraphum*, *D. poitaei* [= *Graphina virginea*], *D. pruinosum*, and *D. soozanum* [≡*Graphina soozana*] (Jia & Wei 2016, Kalb et al. 2004, Lamb 1963, Meng & Wei 2008, Nakanishi et al. 2003, Thrower 1988, Wang Yang & Lai 1973, Wei 1991, Wei et al. 2013, Wu & Qian 1989, Zahlbruckner 1933). Here we describe a new species collected in Fujian Province, China, for which we propose the name *Diorygma fuscum*.

Materials & methods

Specimens are housed in Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L). A dissecting microscope (Olympus SZX12) and a light microscope (Olympus BX51 & Nikon Eclipse-55i) were used for the morphological and anatomical studies. Measurements and illustrations were taken from the manual cross-sections of fruit bodies in water. Amyloidity of the ascospores was tested using Lugol's solution. Spot tests with KOH (20%) were performed on the thallus surface and on thin thallus sections. The lichen substances were detected and identified by thin-layer chromatography (Culberson & Kristinsson 1970; Culberson 1972; White & James 1985).

Taxonomy

Diorygma fuscum Jian Li bis & Z.F. Jia, **sp. nov.** Pl. 1

Fungal name FN 570263

Differs from *Diorygma pruinosum* by its smaller ascospores and the presence of stictic acid.

Type: China. Fujian Province, Jianou City, Fangdao Town, Wanmulin, 27°02′N 118°08′E, alt. 310 m, on bark, 3/VI/2007, Q.F. Meng FJ1280 (**Holotype**, HMAS-L 137193).

Etymology: The epithet refers to the brownish mature muriform ascospores.

Thallus crustose, pale grey to olive-grey, 60–100 µm thick, surface uneven to slightly rugose or warty, without soralia or isidia; pseudocortex indistinctly developed, 5–10 µm thick, partly lacking; algal layer 30–40 µm thick; medulla poorly developed.

Ascocarps numerous, lirellate, often flexuous branched, immersed in the thallus when young, becoming open and ± raised when older, whitish, powdery, acute or rounded at the ends, 1–4 × 0.3–2 mm; disc surrounded by entire (in young apothecia) raised thalline margins, opened, rarely ± convex, with thick and white pruina, often showing fissures when older; exciple divergent, laterally uncarbonized, rudimentarily developed, consisting of a weakly and irregularly or brownish hyphal tissue intermingled with parts of the substrate, carbonization sometimes restricted to the basal position; hymenium 100–180 µm high, not inspersed, I+ weakly bluish violet; epithecium usually distinctly developed, consisting of intermingled anastomosing, hyaline or brownish paraphysis tips with short ± globular cells, hyaline granules, and dead hyphae; paraphyses 1–2 µm diam., with a thick gelatinous wall, often anastomosing, especially in the upper part of the hymenium and near the asci. Ascospores 8 per ascus, hyaline to brownish (when mature), muriform, spore locules of equal size, often arranged in rows, 10–14/3–4-locular, 40–60 × 12–18 µm, I+ violet, with thin halo.

Pycnidia not seen.

Corticolous.

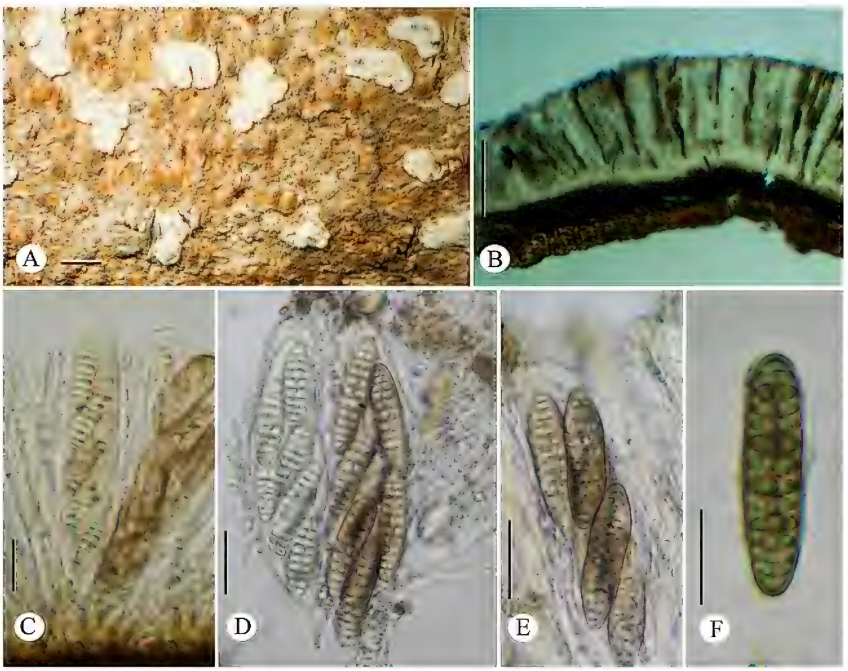


Plate 1. (holotype, HMAS-L 137193). A. Thallus with apothecia; B. Cross-section of apothecium; C. Asci with ascospores, showing the thickened top of ascus; D. Asci with hyaline to brownish ascospores. E. Ascus with brownish ascospores. F. Mature ascospore with thin halo. Scale bars: A = 1 mm; B = 100 µm; C–F = 20 µm.

Chemistry: Stictic acid (major), constictic, hypostictic and hypoconstictic acids (minor, trace or absent).

Additional specimens examined: **CHINA. Fujian Province, Jianou City**, Fangdao Town, Wangmulin, alt. 400 m, 1/VI/2007, Q.F. Meng FJ1059 (HMAS-L 137198); alt. 420 m, 1/VI/2007, Q.F. Meng FJ860 (HMAS-L 137197); alt. 310 m, 3/VI/2007, Q.F. Meng FJ697 (HMAS-L 137196), FJ1278 (HMAS-L 137195), FJ1279 (HMAS-L 137194); alt. 300 m, 3/VI/2007, J. Li FJ630 (HMAS-L 137200); alt. 540 m, 2/VI/2007, J. Li FJ1066 (HMAS-L 137199).

Ecology. *Diorygma fuscum* grows on bark in relatively dry and open situations from lowland primeval forests in subtropical area of China. Associated lichens include *Graphis hossei* Vain. and other species of *Graphidaceae* and *Lecanora*.

Remarks: *Diorygma fuscum* is morphologically similar to *D. pruinosum* (Eschw.) Kalb et al., which differs in having 1-spored asci, larger ascospores (95–170 × 19–50 µm), and the presence of protocetraric acids. The new lichen

species also resembles *D. erythrellum* (Mont. & Bosch) Kalb et al. and *D. poitaei* (Fée) Kalb et al. in producing 8-spores per ascus and similarly sized muriform ascospores (30–65 × 12–20 µm in *D. erythrellum*; 40–65 × 10–18 µm in *D. poitaei*), but differs in having opened discs, a slightly carbonized proper exciple at the base, and the presence of stictic acid (major); *D. erythrellum* differs in containing norstictic acid (major), connorstictic acid (minor or trace), and stictic acid (trace or absent), while *D. poitaei* contains hypostictic and hypoconstictic acids (major) and α-acetylhypoconstictic, constictic, and stictic acids (minor, trace or absent) (Kalb et al. 2004).

Acknowledgements

This study was supported by the National Natural Science Foundation of China (31270066, 31093440, 31493010 & 31493011). The authors are grateful to Dr. Santosh Joshi (CSIR-National Botanical Research Institute, Lucknow, India) and Dr. Hua-Jie Liu (College of Life Sciences, Hebei University, China) for reading and improving the manuscript, and for acting as presubmission reviewers.

Literature cited

Archer AW. 2009. *Graphidaceae*. Flora of Australia 57 (Lichens 5): 84–194.

Cáceres MES. 2007. Corticolous crustose and microfoliose lichens of northeastern Brazil. Libri Botanici 22. 168 p.

Culberson CF. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. Journal of Chromatography 72: 113–125. http://dx.doi.org/10.1016/0021-9673(72)80013-X

Culberson CF, Kristinsson H. 1970. A standardized method for the identification of lichen products. Journal of Chromatography 46: 85–93. http://dx.doi.org/10.1016/S0021-9673(00)83967-9

Feuerstein SC, Cunha-Dias IPR, Aptroot A, Eliasaro S, Cáceres MES. 2014. Three new *Diorygma* (*Graphidaceae*) species from Brazil, with a revised world key. The Lichenologist 46(6): 753–761. http://dx.doi.org/10.1017/S002428291400036X

Jia ZF, Wei JC. 2016. Flora lichenum sinicorum – Vol.13, *Ostropales* (I). Science Press, Beijing. 210 p.

Kalb K, Staiger B, Elix JA. 2004. A monograph of the lichen genus *Diorygma* – a first attempt. Symbolae Botanicae Upsalienses 34 (1): 133–181.

Lamb IM. 1963. Index Nominum Lichenum inter Annos 1932 et 1960 Divulgatorum. The Ronald Press Company, New York. 809 p.

Lima EL, Maia LC, Aptroot A, Cáceres MES. 2013. New lichen species from Vale do Catimbau, Pernambuco, Brazil. The Bryologist 116(4): 327-329. http://dx.doi.org/10.1639/0007-2745-116.4.327

Makhija U, Chitale G, Sharma B 2009. New species and new records of *Diorygma* (*Graphidaceae*) from India: species with convergent exciples. Mycotaxon 109: 379–392. http://dx.doi.org/10.5248/109.379

Meng QF, Wei JC. 2008. A lichen genus *Diorygma* (*Graphidaceae*, *Ascomycota*) in China. Mycosystema 27: 525–531. http://dx.doi.org/10.1017/S002428291300025X

Nakanishi M, Kashiwadani H & Moon KH. 2003. Taxonomical notes on Japanese *Graphidaceae* (*Ascomycotina*), including some new combinations. Bulletin of the National Science Museum (Tokyo), Series B (Botany) 29(2): 83–90.

Sharma B, Khadilkar P. 2012. Four new species of *Diorygma* from India. Mycotaxon 119: 1–10. http://dx.doi.org/10.5248/119.1

Sharma B, Makhija U. 2009a. Four new species in the lichen genus *Diorygma*. Mycotaxon 107: 87–94. http://dx.doi.org/10.5248/107.87

Sharma B, Makhija U. 2009b. New species and new reports of *Diorygma* (lichenized *Ascomycotina*, *Graphidaceae*) from India. Mycotaxon 109: 209–217. http://dx.doi.org/10.5248/109.209

Staiger B. 2002. Die Flechtenfamilie *Graphidaceae*: Studien in Richtung einer natürlicheren Gliederung. Bibliotheca Lichenologica 85: 1–526.

Sutjaritturakan J, Saipunkaew W, Boonpragob K, Kalb K. 2014. New species of *Graphidaceae* (*Ostropales*, *Lecanoromycetes*) from southern Thailand. Phytotaxa 189(1): 312–324. http://dx.doi.org/10.11646/phytotaxa.189.1.22

Thrower SL. 1988. Hong Kong lichens. Urban Council Publication, Hong Kong. 193 p.

Wang Yang JR, Lai MJ. 1973. A checklist of the lichens of Taiwan. Taiwania l8(1): 83–104. http://dx.doi.org/10.6165/tai.1973.18.83

Wei JC. 1991. An enumeration of lichens in China. International Academic Publishers, Beijing. 278 p.

Wei JC, Jia ZF, Wu XL. 2013. An investigation of lichen diversity from Hainan Island of China and prospect of the R & D of their resources. Journal of Fungal Research 11(4): 224–238 (in Chinese).

White FJ, James PW. 1985. A new guide to microchemical techniques for the identification of lichen substances. British Lichen Society Bulletin 57 (Suppl.): 1–41.

Wu JN, Qian ZG. 1989. Lichens. 158-226, in Xu BS (ed.): Cryptogamic flora of the Yangtze Delta and adjacent regions. Shanghai Scientific & Technical Publisher, Shanghai (in Chinese).

Zahlbruckner A. 1933. Flechten der Insel Formosa. Repertorium Novarum Specierum Regni Vegetabilis 31: 194–224. http://dx.doi.org/10.1002/fedr.19330311108

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 723–731

http://dx.doi.org/10.5248/131.723

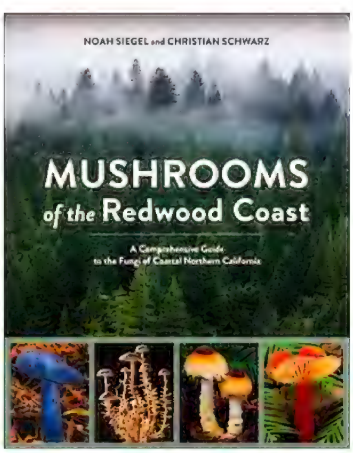
Book reviews and notices*

Lorelei L. Norvell

Pacific Northwest Mycology Service, Portland OR 97229-1309 USA

Abstract—Books reviewed include: General—Mushrooms of the Redwood Coast (Siegel & Schwarz 2016); *Basidiomycetes*—The genus *Mycena* s.l. (Arne Aronsen & Thomas Laessøe).

General


NOAH SIEGEL and CHRISTIAN SCHWARZ
MUSHROOMS
of the Redwood Coast
A Comprehensive Guide
to the Fungi of Coastal Northern California

Mushrooms of the Redwood Coast—a comprehensive guide to the fungi of coastal northern California. By Noah Siegel & Christian Schwarz. 2016. Ten Speed Press [Crown Publishing Group], Berkeley CA <www.randomhouse.com/crown/tenspeed/>. 608 p. ~855 color photos, ISBN 978-1-60774-817-5 US$35 (soft cover), ISBN 978-1-60774-817-2 $18.99 (e-book)

Two and a half decades of sequence analyses have 'steam-rollered' rapid name changes in fungi, often leaving mushroomers and field taxonomists perplexed and decidedly behind the nomenclatural curve. There was a time in the not too distant past that comprehensive regional field guides limited coverage to relatively few species representing the larger and more commonly encountered macrofungi. Fortunately, the recent upsurge of beautifully illustrated and nomenclaturally up-to-date regional field guides (e.g., Trudell & Ammirati 2009, Desjardin & al. 2015) have made life for west coast North American

* Book reviews or books for consideration for coverage in this column should be sent to the *Editor-in-Chief* <editor@mycotaxon.com> 6720 NW Skyline, Portland OR 97229 USA.

mushroomers a lot easier by including revised nomenclature along with striking photos of less commonly encountered fungi.

Mushrooms of the Redwood Coast [advertised by the press as "A comprehensive and user-friendly field guide for identifying the many mushrooms of the northern California coast, from Monterey County to the Oregon border"] is a glorious addition to this new pantheon of field guides. The print copy is a hefty 24 × 19 × 3.8 cm and provides full treatments of over 750 species and references hundreds more. Unfortunately the attractive paper cover on my copy soon separated from the glue strip on the front page, foreshadowing a duct-tape repair in the not too distant future. Glossy inside pages display the sharp clear photos to their best advantage.

The 22-page introductory text is necessarily brief but more than adequately covers the basics. A one-page introduction entices the non-initiated to further coastal forest explorations and precedes an outline of mushroom morphology, fungal ecology, a life cycle diagram, and human-fungal relationships. Six pages devoted to the 'redwood coast' offer a map of the five regions (Far North Coast; North Coast; San Francisco Bay Area & East Bay Hills; Santa Cruz & Peninsula Mountains; and Monterey County and southernmost redwoods) and tree descriptions and superb photos of the ectomycorrhizal northern conifers [Sitka spruce, western hemlock, grand fir], ectomycorrhizal hardwoods [3 live oaks, two deciduous oaks, tanoak, chinquapin, madrone, manzanita], widespread ectomycorrhizal conifers [Douglas-fir, five pine species], and non-ectomycorrhizal trees [the coast redwood itself (!), Monterey cypress, California bay laurel). Two and a half pages are dedicated to collection practices: finding, collecting, and identifying mushrooms, making spore prints, a list of necessities (basket, field notebooks, tackle boxes, waxed paper bags [for which I would substitute aluminum foil], hand lenses, KOH, camera, and food dehydrator), making collections, photographic tips, and collecting for the table. The introduction ends with an excellent overview on "How to read the species descriptions" (the sort of instruction too often ignored by eager would-be identifiers), "General format of the species descriptions" (see below), an explanation of "How to use the pictorial key to the major sections" followed by the six-page pictorial key itself.

Photos paired with descriptions serve as the sole key to species, making this volume definitely geared to the browse-and-point mode of identification. While I do miss more formal keys to species, participation in enough forays and mushroom collecting expeditions suggests that a photo matching routine is perhaps the wisest and most efficient route for would-be identifiers lacking microscopes and reagents—particularly when so many run into dead ends using

written keys. The pictorial key is based on visual appearance, primarily stature and spore print color. Given the rapid name changes and generic shifts, this works relatively well, although my 'generically' trained brain sometimes found itself confused at discovering a species in one section I anticipated in another. The authors sub-divide some of the more unwieldy sections: for example, the notorious 97-page 'white-spored multitude' (divided pictorially into 'large' vs. 'small') is synoptically apportioned into groups A–N, while the well-populated bolete section is helpfully sorted according to its 16 long-accepted (*Boletus, Leccinum, Suillus*) and quite recent (*Butyriboletus? Rubroboletus?*) genera. The other 27 sections include chanterelles & gomphoids; *Amanita; Cystoderma* + *Cystodermella; Lepiota* & allies; *Agaricus* + *Melanophyllum;* dark-spored mushrooms; brown-spored decomposers; mycorrhizal brown spored mushrooms (3 sections: *Inocybe, Hebeloma, Phaeocollybia*); *Cortinarius; Entoloma* (2 sections: large, small)*; Pluteus* and allies; *Russula; Lactarius;* waxy caps (2 sections: I, II); pleurotoids; gilled boletes; polypores and allies; shelflike, conklike, and rosette-forming polypores; crusts; toothed; corals; clubs; puffballs, earthballs & earthstars; stinkhorns; bird's nests; truffles; jellies; morels, false morels & elfin saddles; and cup fungi. I was pleased to see a gratifyingly large number of small to tiny mushrooms over which I have puzzled for years. The species represented seem comprehensive, although one local forayer has observed that as the authors collected during California's recent and very long drought, there are undoubtedly a great many species they never had the opportunity to capture. Nonetheless I was personally charmed by the inclusion of six beautifully photographed *Phaeocollybia* species (all accurately identified) with reference to 14 others!

Each section outlines its genera with their diagnostic characters. Individual species treatments each provide a color photo, Latin name and authority, often a "common" name (some actually common, the remainder useful inventions), and a formal technical description of cap, gills/other fertile surfaces, stipe, veil (including partial veil & volva), flesh, odor & taste, KOH or other chemical reactivity, spore deposit, and microscopic details (always spore shape & size; other diagnostic characters when helpful). Noting that the microcharacters provided are minimal, Siegel & Schwarz wryly observe: "There's still much to be learned about the range and significance of variation in microscopic features of mushrooms—our data are representative but not definitive. Please seek out measurements from other sources and tell us what you learn!" Each treatment is rounded out with information on ecology (more comprehensive than usually found in field guides), edibility, the all-important COMMENTS paragraph, and synonyms, misapplications, and other nomenclatural notes.

Each major species entry (1–2 per page) consists of a photo paired with text. The photography is stellar throughout, expecially noticeable in the introductory three large full-page plates and numerous half-page photos; the smaller (~1/6 page) photos accompanying most species descriptions appear equally clear, but fans (I am one) of the volume should consider also purchasing the online version so as to zoom these smaller photos for details not easily seen on the printed page. With no photographers credited (either by the photos or in the acknowledgments), we should assume that the two author-photographers deserve kudos for capturing so many fine photos in the field.

The authors have adopted Arora's (1986) term 'group' (e.g., *Lyophyllum decastes* group, *Xerocomus subtomentosus* group, *Scutellinia scutellata* group) and have introduced placeholder names (e.g., *Craterellus tubaeformis*, *Hygrocybe punicea*, *Russula cyanoxantha*, here all followed by 'sensu CA'), particularly useful when depicting taxa known to differ from their European sobriquets but which are yet to be described. [What made Arora's 'group' so wonderful for so many years is that it satisfied those anxious to name a specimen while simultaneously indicating that more research is needed to suss out the 'real' identification.] No doubt equally satisfying to the 'namers' among us is that the authors are not shy about providing provisional names by enclosing unpublished epithets (e.g., *Dendrocollybia* "*pycnoramella*", *Leptonia* "*Ruby Grapefruit*", *Xerocomellus* "*diffractus*") and new combinations ("*Phaeoclavulina*" *myceliosa*, "*Gliophorus*" *flavifolius*, "*Xerocomellus*" *mendocinensis*) in quotation marks. Exceedingly helpful to the field mycologist, this also suggests a degree of nomenclatural trust on the part of Siegel & Schwarz that unethical competitors will not rush to publish the names ahead of them.

Regarding misapplications and synonomies, the authors note, "Californian mushrooms are often quite different in morphology, microscopic features, ecology, and genetics from their European namesakes, but until a new name is published, the most effective way of referring to them may be to use an epithet we know to be incorrect. We recommend taking a practical view of things: incorrect names will be used to convey information, and if they succeed in doing so without creating any new confusion, don't worry too much about it." Thus noting that *Cortinarius percomis* is a European name long misapplied for *C. citrinifolius*, *Neoalbatrellus* (*Albatrellus*) *caeruleoporus* is an eastern North American name misapplied for *N. subcaeruleoporus*, and *Lactarius vinaceorufescens* & *L. chrysorrheus* are both eastern North American names misapplied for *L. xanthogalactus* help link a familiar image and the new correct name together. Synonyms serve a similar function (e.g., *Atheniella adonis* ≡ *Mycena adonis*; *Lichenomphalia umbellifera* = *Omphalia ericetorum* [somewhat

baffling to me, given that the US government's Northwest Forest Plan listed *Omphalina ericetorum*]; *Mycetinus copelandii* ≡ *Marasmius copelandii,* with a highly informative note citing recent genetic work that supports the species in *Gymnopus; Bolbitius titubans* = *B. vitellinus*). Some 'newer' names lack synonyms—the earlier placement of *Tapinella atrotomentosa* in *Paxillus* and *Annulohypoxylon thouarsianum* in *Sphaeria* are not noted—but such omissions are few. In general, I greatly appreciated finding so many 'hot-off-the-press' names with origins in multi-gene sequence analyses; these no doubt owe their presence in the volume to the careful review of Else Vellinga, whom Siegel & Schwarz thank first in their acknowledgments.

The volume closes with a list of future directions (mycofloristics, conservations, climate change, biogeography, systematics, sequence database quality, evolutionary and ecological synthesis), a 3-page glossary, resources for the mycophile, bibliography, general index, and genus & species index.

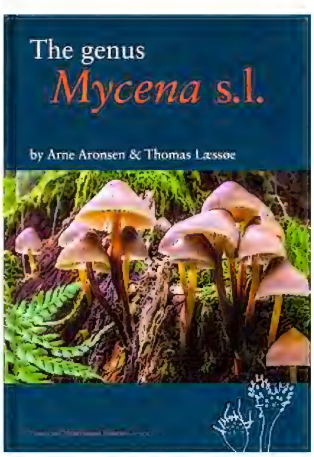
Overall the field guide is engagingly written and with understated humor highly appreciated here). I highly recommend this book.

Arora D. 1986. Mushrooms demystified (2nd edn.). Ten Speed Press, Berkeley CA. 959 p.

Trudell S, Ammirati J. 2009. Mushrooms of the Pacific Northwest. Timber Press, Portland OR. 351 p.

Desjardin DE, Wood MG, Stevens FA. 2015. Timber Press, Portland OR. 560 p.

Basidiomycetes



Fungi of Northern Europe—Vol. 5. The genus *Mycena* s.l. By Arne Aronsen & Thomas Læssøe. 2016. Svampetryk <www.svampe.dk>, Narayana Press, Gylling, Denmark. 373 p. ~378 color photos, ~116 micro-drawings. ISBN 978-87-983581-2-1. Price (excl. postage): 450 kr. (375 kr. for Danish Mycological Society members).

How monographs have changed! Eighteen years ago I regularly labored far into the night over scores of *Mycena* collections while poring over microdrawings in my venerable Alexander Smith (1947), Maas Geesteranus (1992), Rexer (1994),

and unpublished keys and notes shared by Scott Redhead and riffling through the far-too-few color plates in Breitenbach & Kränzlin (1991). Not until Robich (2003) landed on my library shelves did I have a full-color monograph dedicated to these beautiful agarics—and *Mycena* is a genus that wears its colors very well, indeed.

Aronsen & Læssøe's new volume is as beautiful as the mushrooms it depicts. Its size, large enough to be encyclopedic yet small enough to take to (if not into) the field (23 × 17 × 3 cm), and its durable hard cover surrounds semi-glossy easy-to-read glare-free pages bearing text and glossy photos that are especially sharp and clear. Photo credits, most often placed unobtrusively to the right of each photo, cite not only photographer and country but also collection number, a wonderful addition I've not noticed in other monographs. Of the 160 mycenas recorded from Europe, 115 are fully described here.

Authors who cover a genus in the broad sense must contend with when (or whether) to fit the nomenclature to taxonomic breakthroughs. As Aronsen & Læssøe note in their preface (written in May 2016), "It has become increasingly clear that *Mycena* is not a monophyletic entity, and we have thus chosen to title this volume *Mycena* sensu lato.... Most taxa have been accepted or left within the genus *Mycena* but the two satellite genera, *Roridomyces* [Rexer 1994] and *Resinomycena* [Redhead & Singer 1981] have become more or less well established and are also ad interim recognized here, whilst newer introductions such as *Atheniella* (for *M. adonis* a.o.) [Redhead 2012] and *Phloeomana* (for *M. speirea* a.o.) [Redhead 2013] have not been formally recognized in this book, although we accept that the genus *Mycena* as here circumscribed will have to be split. The old generic name *Prunulus,* reintroduced by Redhead & co-workers for *Mycena* sect. *Calodontes,* is likewise not treated as an independent genus in this treatment." In their historical recapitulation, the authors also draw attention to the on-going battle between lumpers and splitters: ["... unlike Kühner (1923), Singer (1938)] excluded some of the inamyloid species, and transferred them to his newly erected genus *Hemimycena*.... He, likewise, transferred another group of species (mainly with huge pleuro- and cheilocystidia and ± ornamented spores to the genus *Mycenella.* He was in other words a splitter, while Kühner tended to be a lumper. In the era we live in now, the splitters are having the upper hand..... Within the temperate world of the Northern Hemisphere the baton was taken over by Rudolph Arnold Maas Geesteranus.... Although he rarely worked with living specimens, he, nevertheless, produced a monumental and long lasting monograph. He excluded *Mycena rorida* from the genus mainly based on the structure of the pileipellis, and Rexer (1994) erected the genus *Roridomyces* to accommodate this and six other species. Another

deviating *Mycena,* known under a host of names ... was also excluded by Maas Geesteranus and accepted as *Resinomycena saccharifera....*"

In their later discussion on phylogeny, the authors offer further generic insights: "...it has become clear that *Mycena* as understood by Kühner, Singer, and Maas Geesteranus ... is polyphyletic. Unfortunately, various efforts have not so far [led] to a paper that provides a useful overview of the phylogenetic position of the taxa that are and once were accepted within the genus. Early poorly resolved trees have been used to create two new genera, and one old genus has been accepted by some. ... *Atheniella* for e.g. *M. adonis* and *Phloeomana* for *M. speirea* were created by Redhead and collaborators (Redhead 2012) in a very brief contribution. Redhead (2016a, b, c), equally brief, added four more species to *Phloeomana* ... and in Gminder (2016) another *Atheniella* was added. It will be interesting to see whether a situation that parallels that seen in *Boletus* s.l.—hyper splitting—will be the trend in mycenoid fungi. In this context we have had to be conservative since no good phylogenetic trees are publicly available." In part, these comments address a controversy revolving around the recent trend toward exceedingly brief publications that fulfill the letter of the International Code of Nomenclature, if not the spirit, by presenting a name, diagnosis, holotype, and relatively little discussion placing the new taxon in context. While I remain at heart a splitter (finding smaller monophyletic genera easier to master than larger polyphyletic ones), this move toward minimalist publishing is hardly helpful. Unfortunately additional sequence analyses or other as-yet untapped scientific innovations are unlikely to settle the splitter vs. lumper controversy. When it comes down to it, taxonomy seems always to remain a matter of opinion.

The formal introduction and a brief paragraph on (very) basic materials and methods (noting that the names used more or less agree with those accepted by Index Fungorum and MycoBank) are followed by 23 pages devoted to "The genus *Mycena* s.l." This chapter lists accepted generic synonyms followed by a generic description. Macroscopic features are accompanied by stunning detailed photos of ephemeral characters (including one of the best photos of a separable elastic gill thread I've seen) and the discussion of important microscopic features includes sketches of cheilocystidial types (p. 19) and pileipellis types and setae. [Drawings throughout the book are elegantly minimalist but get the job done.] "Ecology and habitat" pairs six pages of excellent plates of representative species with habitats (e.g., *M. chlorantha* in dunes, *M. aetites* on lawns, *M. clavicularis* in pine forests). Brief paragraphs on conservation, seasonality, and development (one sentence referring to Rexer's thesis), cytology & culture studies, bioluminescence, toxicity, and parasites, and phylogeny (see above) follow.

Next comes a brief discussion of systematic arrangement & species concepts and a list of the 32 sections (with species covered), both according to Maas G.

Particularly helpful are the six pages of photos and brief descriptions of genera often confused with *Mycena*. Discussed here are two covered in the volume (*Resinomyces, Roridomyces*) and 26 others not included (*Arrhenia, Baeospora, Blasiphalia, Chromosera, Chrysomphalina, Collybia, Contumyces, Delicatula, Dendrocollybia, Fayodia, Gamundia, Gyroflexus/Sphagnomphalia, Hemimycena, Hydropus, Hygroaster, Lichenomphalia, Loreleia, Marasmiellus, Mycenella, Omphalina, Pseudobaeospora, Rickenella, Sphagnurus, Strobilurus,* and *Xeromphalina*).

Three dichotomous keys (all needed) are presented: [1] keys to mycenoid genera & species (4 pages), [2] a macro-based key further divided into Keys A–K (18 pages), and [3] a micro-based key (12 pages), where an entry key allocating 5 species also provides leads to Keys I–III. Although I would not have presented the spore Q >1.2 vs Q <1.2 as the first couplet in Key I, I am loath to criticize any key that has not been personally tested in the field and lab. These dichotomous keys are augmented by an extremely helpful synoptic key to mycenas sorted by habitat/substrate types.

The 115 species treatments comprising the bulk of the volume (pp. 78–333) do not disappoint. The accepted taxonomic name and nomenclator (followed by basionyms, synonyms, and misapplications) stand at the top of each first page above a 2–3 line diagnosis. A complete technical description, ecology & distribution data, and discussion follow. The text is accompanied by 2–5 excellent photos (most in situ, but often shown with a plate (taken with macro-lens or dissecting microscope) detailing characters that might otherwise be missed. *Mycena mitis,* a rare mushroom not captured fresh in the field, is represented by a painting and line drawing. While the line drawings are rather small and definitely not as detailed or elaborate as those found in Smith (1947), Rexer (1994, who helpfully grouped elements), Maas G. (1992), and Robich (2003, by far the most intricately rendered), those in Aronsen & Læssøe seem somehow more accessible and less likely to confuse. Two species also offer a table or list comparing two look-alikes (e.g., *M. polygramma* vs. *M. vitilis, M. filopes* vs. *M. metata*), which I found particularly helpful.

Two new species, fully treated on pages 220–221 (*M. pasvikensis*) and 270–271 (*M. mucoroides*), are also formally published on p. 334, accompanied by the required MycoBank (& GenBank) numbers, etymology, diagnosis, and type information. A note on the messy nomenclature surrounding *M. rosea* nom. illeg. shows Bulliard's plate used by Maas G. to lectotypify the species with Bulliard as author. The taxonomic treatments conclude with comments

on 47 taxa not treated in the main text, 11 rejected names, 19 dubious taxa, 4 extralimital taxa, 37 excluded taxa now transferred to other genera, and one 'misinterpretation.' References and a taxonomic index round out the volume.

Its stunning sharp yet luminous photos, uncluttered elegant design, and wealth of information make THE GENUS *MYCENA* S.L. a joy to own, read, and use. A reliable reference that is simultaneously striking and restful fosters the illusion that the reader should easily be able to master the genus with no problem—an illusion that will keep many of us soldiering on. I highly advise everyone intrigued by these beautiful delicate agarics (and isn't that everyone?) to add this volume to their libraries. You won't regret it.

Breitenbach J, Kränzlin F. 1991. Fungi of Switzerland 3. Verlag Mycologia, Lucerne. 361 pp., 349 col. ill.

Gminder A. 2016. Nomenclatural novelties. Index Fungorum 302: 1.

Kühner R. 1938. Le genre *Mycena*. Encyclopédie mycologique X. P. Lechevalier, Paris. 710 pp. (in French)

Maas Geesteranus, R.A. 1992. Mycenas of the northern hemisphere. I. Studies in Mycenas and other papers. 391 pp.; II. Conspectus of the mycenas of the northern hemisphere. 493 pp.; Koninklijke Nederlandse Akademie van Wetenschappen verhandelingen, afd. Natuurkunde, Amsterdam.

Redhead SA. 2012. Nomenclatural novelties. Index Fungorum 14: 1.

Redhead SA. 2013. Nomenclatural novelties. Index Fungorum 15: 2.

Redhead SA. 2016a. Nomenclatural novelties. Index Fungorum 289: 1.

Redhead SA. 2016b. Nomenclatural novelties. Index Fungorum 290: 1

Redhead SA. 2016c. Nomenclatural novelties. Index Fungorum 291: 1

Redhead SA, Singer R. 1981. *Resinomycena* gen. nov. (*Agaricales*), an ally of *Hydropus, Mycena* and *Baeospora*. Mycotaxon 13: 150–170.

Rexer K-H. 1994. Die Gattung *Mycena* s.l. Studien zu ihrer Anatomie, Morphologie und Systematik. PhD dissertation, Fakultät für Biologie der Eberhard-Karls-Universität Tübingen. 318 pp. (in German)

Robich, Giovanni. 2003. *Mycena* d'Europa. A.M.B. Fondazione Centro Studi Micologici, Trento, Italy. 728 p. (in Italian)

Smith, Alexander H. 1947. North American species of *Mycena*. University of Michigan Press, Ann Arbor. 521 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 733–734

http://dx.doi.org/10.5248/131.733

Nomenclatural novelties and typifications proposed in Mycotaxon 131(3)

Anaverticicladus P.M.O. Costa, Malosso & R.F. Castañeda [MB 816930], p. 688

Anaverticicladus uncinatus P.M.O. Costa, Malosso & R.F. Castañeda [MB 816931], p. 688

Boletus durhamensis B. Ortiz, Bessette & McConnell [MB 810115], p. 706

Capsicispora J.Y. Wang, Yu M. Cai & X.G. Zhang [MB 81802], p. 560

Capsicispora mycophila J.Y. Wang, Yu M. Cai & X.G. Zhang [MB 81803], p. 560

Corynesporopsis obclavata Jian Ma [MB 816248], p. 583

Diaporthe henanensis Yi Yang, H.Y. Wu & Meng Zhang [MB 804356], p. 649

Diorygma fuscum Jian Li bis & Z.F. Jia [FN 570263], p. 718

Diploschistes tianshanensis A. Abbas, S.Y. Guo & Ababaikeli [MB 804328], p. 569

Ellisembia henanensis J.W. Xia & X.G. Zhang [MB 818289], p. 598

Erysiphe acantholimonis J.G. Song, B. Xu & H.D. Shin [MB 815918], p. 624

Gymnopus ramulicola T.H. Li & S.F. Deng [MB 815128], p. 665

Harmoniella campanaensis Madrid, D. Torres & V. Silva [MB 815759], p. 536

Hemithecium hainanense Z.F. Jia [FN 570071], p. 672

Laboulbenia camerunensis T.W. Wang & Haelew. [MB 811237], p. 615

Lithothelium bermudense F. Berger, LaGreca & Aptroot [MB 815588], p. 528

Marthamyces coronadoae Raymundo, R. Valenz. & Esqueda [MB 815275], p. 522

Periconia notabilis Chuaseehar., Somrith. & Boonyuen [MB 815470], p. 503

Phaeomonilia nanningensis C.L. Yang & X.G. Zhang [MB 818085], p. 548

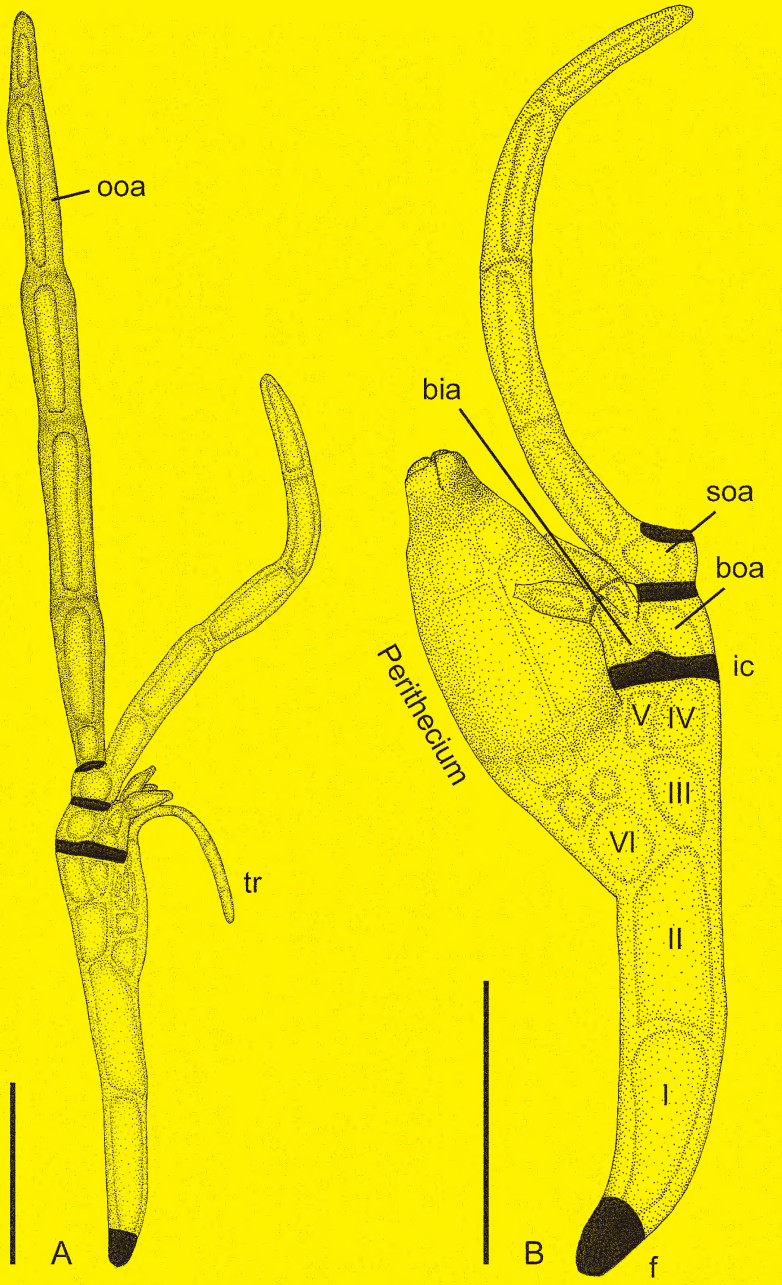
Pseudoacrodictys ambigua J.M. Gao & X.G. Zhang [MB 818098], p. 559

Puccinia tatarinovii Kom. & Tranzschel 1939 (lectotypified & epitypified), p. 657

Rosellinia hainanensis Wei Li bis & L. Guo [FN 570257], p. 542

Sporidesmiella jiulianshanensis Jian Ma [MB 816247], p. 578

Sporidesmiella lushanensis Jian Ma [MB 816246], p. 575
Stanjehughesia jiangxiensis Jian Ma [MB 816249], p. 585
Thozetella coronata J.S. Monteiro, R.F. Castañeda & Gusmão [MB 814790], p. 607
Thozetella ypsiloidea J.S. Monteiro, R.F. Castañeda & Gusmão [MB 814791], p. 608
Tubulicrinis martinicensis G. Gruhn, Hallenb. & Courtec. [MB 815644], p. 632



Laboulbenia camerunensis sp. nov.
(Wang, Haelewaters & Pfister— Plate 1, p. 617)
Tristan W. Wang & Donald H. Pfister, *artists*